



วิทยาลัยวิทยาศาสตร์สาธารณสุข  
College of Public Health Sciences  
Chulalongkorn University



**UMS**  
Universitas Muhammadiyah Surakarta

# Proceedings of The 22<sup>nd</sup> International Conference of Public Health Sciences

4<sup>th</sup> October 2022  
A Virtual Conference

College of Public Health Sciences  
Chulalongkorn University, Thailand

Faculty of Health Science  
Universitas Muhammadiyah Surakarta, Indonesia

Department of Health and Welfare  
University of Taipei, Taiwan

**Proceedings of  
The 22<sup>nd</sup> International Conference of  
Public Health Sciences**

4 October 2022  
A Virtual Conference

College of Public Health Sciences  
Chulalongkorn University, Thailand

Faculty of Health Science  
Universitas Muhammadiyah Surakarta, Indonesia

Department of Health and Welfare  
University of Taipei, Taiwan



# Preface

---

Chulalongkorn University has its own vision to be a world-class national university that generates the knowledge and innovation necessary for the creative and sustainable transformation of Thai society. In order to accomplish this vision, Chulalongkorn University has been supporting every Faculties, Institutes, Colleges and etc. within the university to conduct academic activities including in-class teaching, research, and conferences as we have today. The College of Public Health Sciences is the academic entity that emphasizes the teaching-learning on graduate level in the field of public health and public health sciences. It utilizes a mechanism to combine research both in public health and public health sciences in response to research questions regarding health and public health issues within Thailand and the region. The College has been aware of the important missions of the University in transferring the body of knowledge in form of academic services to the society. The College thus designates to hold Public Health Sciences academic conference on an annual basis. Today marks our 22<sup>nd</sup> anniversary.

# Welcome Message

---



On behalf of the College of Public Health Sciences, Chulalongkorn University and Scientific Committees of the 22<sup>nd</sup> International Conference of Public Health Sciences with the theme on “Public Health and Public Health Sciences: The Challenges of changing Era”. I would like to welcome all of you to the College of Public Health Sciences. There will be several presentations reflecting the broad diversity of public health issues. This event will undoubtedly provide an opportunity for all of us to exchange and share knowledge and experiences, resulting in an improvement of Thailand's and the world's public health conditions.

I would like to thank the conference co-host, Faculty of Health Science, Universitas Muhammadiyah Surakarta, Indonesia, and Department of Health and Welfare, University of Taipei, Taiwan as well as the members of the Organizing and Scientific Committees, colleagues and staff for their tireless efforts to organize this conference.

This conference is a unique opportunity for researchers, policy makers, health professionals, academicians, and graduate students to come together and share their knowledge, ideas, and experiences. We have an exceptional line-up of keynote speakers and presentations that will provide valuable insights into the latest trends and developments in public health and public health sciences. We hope that you will take advantage of this opportunity to network with your peers, learn from experts, and contribute to the advancement of your field. Once again, welcome all of you to the 22<sup>nd</sup> International Conference of Public Health Sciences.

Prof. Sathirakorn Pongpanich, Ph.D.  
Chairperson, Executive Committee, 22<sup>nd</sup> ICPHS  
Dean, College of Public Health Sciences,  
Chulalongkorn University, Thailand



On behalf of Faculty of Health Sciences, University Muhammadiyah Surakarta. It is an honor to warmly welcome all of participants to the 22nd International Conference of Public Health Sciences 2022, and I sincerely thank you for all of the commitments and efforts in planning and presenting this innovative and valuable event. I would also like to extend a warm welcome and express my heartfelt gratitude to all keynote speakers at this conference from whom we can learn and benefit from the knowledge presented as well as the other presenters' topics.

ICCPHS has expanded on previous years' meetings by introducing additional several more categories for scientific sessions, making this conference greater and more exciting than its predecessors. This event will undoubtedly result in many new and exciting collaborations. I would like to take this opportunity to thank the gallant organizing committee for making this international conference possible and enjoyable.

I wish you all a wonderful moment at this event and much success with your presentations and the formation of new and innovative collaborations. In conclusion, I would like to express my gratitude to all conference presenters, particularly those members who will be making their international scientific debut at ICCPHS 2022.

Dr. Umi Budi Rahayu, S.Fis., Ftr., M.Kes  
Dean, Faculty of Health Science,  
Universitas Muhammadiyah Surakarta, Indonesia



On behalf of the Department of Health and Welfare, University of Taipei (UT), I would like to thank Chulalongkorn University for inviting UT to co-host the 22nd International Conference of Public Health and Public Health Sciences.

Many emerging diseases have spread rapidly and globally in recent years as international transportation has become increasingly convenient. Examples include COVID-19, dengue fever, Zika, and several others, which are huge public threats to people in the Asian region.

Geographically, we three countries are in the same neighborhood, and in terms of disease control, we are in a community of common destiny.

Quick and accurate diagnosis of infected patients is important for controlling the spread of the disease, especially when there are many asymptomatic infections. Thanks to advances in medical science and improvements in screening and laboratory techniques, vaccine development is prompt, the duration of disease detection is shorter, and laboratory sensitivity and specificity are better.

In recent years, Taiwan and Thailand have collaborated in the Bio-Circular-Green economy, as well as in agriculture and medicine. Taiwan and Indonesia also collaborate in food safety and science, IoT, and electronic engineering.

By exchanging information and technical cooperation, Thailand, Indonesia and Taiwan can also bring more collaboration in public health sciences in the future in this region.

Thank you again for your invitation and participation.

Associate Professor Yeong-Ren Chen, Ph.D.  
Chair, Department of Health and Welfare,  
University of Taipei, Taiwan

# Organizers

---

## The 22<sup>nd</sup> International Conference of Public Health Sciences

### Organizers

College of Public Health Sciences  
Chulalongkorn University, Thailand

Faculty of Health Science  
Universitas Muhammadiyah Surakarta, Indonesia

Department of Health and Welfare  
University of Taipei, Taiwan

### Organizing Committees

Prof. Chitlada Areesantichai, Ph.D.  
Assoc. Prof. Wattasit Siriwong, Ph.D.  
Asst. Prof. Tepanata Pampaibool, Ph.D.  
Assoc. Prof. Kanchana Rungsihirunrat, Ph.D.  
Asst. Prof. Montakarn Chuemchit, Ph.D.  
Assoc. Prof. Nutta Taneepanichskul, Ph.D.  
Asst. Prof. Pokkate Wongsasuluk, Ph.D.  
Asst. Prof. Wandee Sirichokchatchawan, Ph.D.  
Asst. Prof. Pramon Viwattanakulvanid, Ph.D.  
Asst. Prof. Anchalee Prasansuklab, Ph.D.  
Asst. Prof. Kraiwuth Kallawicha, Ph.D.  
Asst. Prof. Anuchit Phanumartwiwath, Ph.D.  
Nuchanad Hounnaklang, Ph.D.  
Onuma Songram, Ph.D.  
Narumol Bhummaphan, Ph.D.  
Alessio Panza, M.D., DTM&H  
Prof. Karl Jakob Neeser, Ph.D.  
Peter Xenos, Ph.D.  
Andrea Bruni, MD, Psychiatrist  
Assoc. Prof. Samuel Shih-Chih Wang, Ph.D.  
Assis. Prof. Tzu-Hsuen Yuan, Ph.D.  
Assis. Prof. Wan-Lin Chiang, Ph.D.  
Prof. Tung-Liang Chiang, Sc.D.  
Distinguished Prof. Chang-Chuan Chan, Sc.D.

Mitoriana Porusia, SKM., M.Sc.

Arif Widodo, M.Kes, Ph.D.

## **Organizing Committees**

Dian Hudiyawati

Yuli Kusumawati, SKM., M.Kes(Epid), Ph.D.

Noor Alis Setiyadi, Ph.D.

Ns.Wachidah yuniartika, S.Kep, M.Kep

Nur Lathifah Mardiyati, M.S.

Winarsih Nur Ambarwati, S.Kep. Ns., M.Kep

Supratman, Ph.D.

Faizah Betty Rahayuningsih, A. S.Kep., M.Kes, Ph.D.

Dwi Rosella Komalasari, F.tr., M.Fis., Sp.Vest., Ph.D.

Umi Budi Rahayu, SSTFT., F.tr., M.Kes, Ph.D.

Ms. Kunyanin Sridachati

Ms. Satapanee Nintarati

Ms. Surada Suwannapak

# Keynote Lectures

---

## Topic I Precision Public Health for a Resilient Society



### **Prof. Chang-Chuan Chan**

*Institute of Environmental and Occupational Health Sciences, National Taiwan University*

Director, Center for Asia-Pacific Resilience and Innovation (CAPRI)

Chair, International Advisory Board, Asia-Pacific Hub

Chang-Chuan Chan is a Distinguished Professor at the Institute of Environmental and Occupational Health Sciences (formerly the Institute of Occupational Medicine and Industrial Hygiene), College of Public Health, National Taiwan University (NTU) (Council on Education for Public Health accredited). He was the ninth Dean of the College of Public Health and Director of the Global Health Center and Population Health Research Center at NTU. He is a member of the Association of Pacific Rim Universities (APRU) Global Health Program Advisory Group and the head of delegations for Taiwan in the M8 Alliance of Academic Health Centers, Universities and National Academies. He is also an advisor to the Taipei City Mayor, a member of the Taipei 2050 Vision Committee, and a member and Vice Executive Officer of the Council for Sustainable Development, Taipei City Government.

Chan has held prominent positions in international societies including councilor of the International Society for Environmental Epidemiology (ISEE) from 2015 to 2017, councilor of the International Society of Exposure Analysis (now International Society of Exposure Science) from 2008 to 2011, steering committee member of APRU Global Health Program from 2014 to 2016, a member of the board of directors at Association of Schools and Programs of Public Health (ASPPH), chair of the ISEE, Asia and Western Pacific Chapter (ISEE-AWPC) from 2016 to 2020, and chairman of the Taiwan Society for Risk Analysis from 2008 to 2015. He was the Director of the Institute of Occupational Medicine and Industrial Hygiene at NTU from 1999 to 2005 and Associate Dean of the College of Public Health, NTU, from 2011 to 2017.

Chan holds a Doctor of Science in Air Pollution Control and Master of Science in Industrial Hygiene and Air Pollution Control from the Harvard T.H. Chan School of Public Health and a Bachelor of Science in Public Health from NTU. He has been a leading researcher in air pollution for more than 20 years, focusing on environmental epidemiology, exposure and risk assessment, and global health governance, with collaborative projects in Malaysia, Thailand, Mongolia, India, South Korea, Japan, United States, and European Union, and has over 200 publications in SCI journals.

## Topic II Integrative Healthcare in Indonesia: Potencies and Challenges



**Dwi Linna Suswardany, S.KM., MPH**

*School of Public Health, Faculty of Health Science, Universitas Muhammadiyah Surakarta Indonesia*

Head of Research and Training Center

Faculty of Health Science (FHS) Universitas Muhammadiyah Surakarta, Indonesia

Head of Special Interest Group in Traditional, Complementary and Alternative Medicine

The National Board of The Indonesian Public Health Association (PP IAKMI), Central Jakarta, Indonesia

**Education**

1. Public Health UNDIP
2. School of Population Health, Faculty of Health Science University of Queensland, Australia

**Knowledge field**

1. Health Management and Policy
2. Traditional, Complementary, Alternative and Integrative Health Service Management

### Topic III Redirection of Public Health Education in a Changing World



**Professor Sathirakorn Pongpanich, Ph.D.**

*College of Public Health Sciences, Chulalongkorn University*

Sathirakorn Pongpanich, Ph.D. is a professor in Health Economics and a Dean at the College of Public Health Sciences, Chulalongkorn University. He is invited to be a visiting professor at many universities and School of Public Health around the world and has served as thesis external examiner since 2000. He is the author and editor of 3 books, as well as numerous research articles. He conducted many researches in Public Health for Thailand Ministry of Public Health, Thai Health Promotion Foundation, World Health Organization (WHO) and others. His areas of interest include One Health, Sciences, Technologies and Innovations in Public Health, Cost of Treatment of Diseases, National Health Account, Tobacco Reduction Campaign, Negotiation and Public Health Administrations, Free Trade Agreement on Health and etc. He is, as well, known as one of experts in negotiation who is participating in important national and international negotiation arenas and offering negotiation training to health professionals in South and Southeast Asian region.

# Conference Program

The 22<sup>nd</sup> International Conference of Public Health Sciences  
 “Public Health and Public Health Sciences: The Challenges of changing Era”

Tuesday 4<sup>th</sup> October 2022

A Virtual Conference

Organized by

College of Public Health Sciences, Chulalongkorn University, Thailand (Host)  
 Faculty of Health Science, Universitas Muhammadiyah Surakarta, Indonesia (Co-Host)  
 Department of Health and Welfare, University of Taipei, Taiwan (Co-Host)

<b>08.00 – 08.30</b>	<b>Registration</b>
<b>08.30 – 09.20</b>	<b>Opening Session</b>
	<b>Report</b>
	<p><b>By Professor Sathirakorn Pongpanich, Ph.D.</b>          Dean, College of Public Health Sciences, Chulalongkorn University</p> <p><b>Dr. Umi Budi Rahayu, S.Fis., Ftr., M.Kes</b>          Dean, Faculty of Health Science, Universitas Muhammadiyah Surakarta</p> <p><b>Associate Professor Yeong-Ren Chen, Ph.D.</b>          Chair, Department of Health and Welfare, University of Taipei</p>
	<b>Welcome Remarks</b>
	<p><b>By Professor Bundhit Eua-arporn, Ph.D.</b>          President, Chulalongkorn University</p>
	<b>Opening Remarks</b>
	<p><b>By Professor Pirom Kamolratanakul, M.D.</b>          Chairperson, Chulalongkorn University Council</p>
	<b>Outstanding Awards Ceremony</b>
	<p><b>2022 Distinguished College of Public Health Sciences Researcher Award</b>          under the Professor Emeritus Charas Suwanwela, M.D. Fund</p> <p><b>Presented by</b> Professor Emeritus Charas Suwanwela, M.D.</p> <p><b>2022 Distinguished Award for Thai Traditional Medicine</b>          under the Prince KromLuang Wongsadhirajsanit Fund</p> <p><b>Presented by</b> Professor Emeritus Wongkulpat Snidvongs, M.D.</p> <p><b>2022 Distinguished Award for Substance Abuse, Alcohol &amp; AIDS</b>          under the Associate Professor Vichai Poshyachinda, M.D. Fund</p> <p><b>Presented by</b> Professor Emeritus Makumkrong Poshyachinda, M.D.</p> <p><b>2022 Distinguished Alumni Award of the College of Public Health Sciences,          Chulalongkorn University</b></p> <p><b>Presented by</b> Professor Pirom Kamolratanakul, M.D.</p> <p><b>Academic Year 2021 Dissertation/Thesis Award</b></p> <p><b>Presented by</b> Professor Bundhit Eua-arporn, Ph.D.</p>

**2022 Distinguished Supporting Staff Award of College of Public Health Sciences, Chulalongkorn University**

**Presented by** Professor Sathirakorn Pongpanich, Ph.D.

**2022 Distinguished Supporting Staff Award of College of Public Health Sciences, Chulalongkorn University**

**Presented by** Professor Sathirakorn Pongpanich, Ph.D.

**09.20 – 09.30**

**Group Photo**

**09.30 – 10.00**

**The 19<sup>th</sup> Professor Emeritus Charas Suwanwela, M.D. Lecture:**

“Mental Health and COVID-19”

**By** Dr. Amporn Benjapornpitak, M.D.

Director-General, Department of Mental Health Ministry of Public Health

**Moderator:** Professor Chitlada Areesantichai, Ph.D.

**10.00 – 10.30**

**Coffee Break**

**10.30 – 12.00**

**Symposium: (Main Room)**

**Topic I:** Precision Public Health for a Resilient Society

**By** Professor Chang-Chuan Chan, Ph.D.

Distinguished Professor, Institute of Environmental and Occupational Health Sciences, National Taiwan University

**Moderator:** Associate Professor Wattasit Siriwong, Ph.D.

**Topic II:** Integrative Healthcare in Indonesia: Potencies and Challenges

**By** Dwi Linna Suswardany, S.KM., MPH

School of Public Health, Faculty of Health Science, Universitas Muhammadiyah Surakarta Indonesia

**Moderator:** Assistant Professor Pramon Viwattanakulvanid, Ph.D.

**Topic III:** Redirection of Public Health Education in a Changing World

**By** Professor Sathirakorn Pongpanich, Ph.D.

Dean, College of Public Health Sciences, Chulalongkorn University

**Moderator:** Associate Professor Nutta Taneepanichskul, Ph.D.

**12.00 – 13.00**

**Lunch**

**13.00 – 14.20**

**Outstanding Award oral Presentation (Main Room)**

**13.00 – 13.20**

**Presentation 1:** Art Psychotherapy and Drug Dependent Treatment

**By** Ms. Janya Jettanasomboon

Social Worker, Thanyarak Songkhla Hospital

**13.20 – 13.40**

**Presentation 2:** Punjasri Herb Company Limited

**By** Mrs. Supatra Chansuvan

Managing Director, Punjasri Herb Company Limited

**13.40 – 14.00**

**Presentation 3:** Physical Activity Promotion Work in Thai Schools

**By** Associate Professor Narongsak Noosorn, Ph.D.

Dean, Faculty of Public Health, Naresuan University

**14.00 – 14.20**

**Presentation 4:** The Impacts of Air Quality at Home on Health

**By** Associate Professor Nutta Taneepanichskul, Ph.D.

Lecturer, College of Public Health Sciences

**Chairperson:** Assistant Professor Montakarn Chuemchit, Ph.D.

**Co-chairperson:** Associate Professor Kanchana Rungsrirunrat, Ph.D.

- 14.20 – 14.35 **Coffee Break**  
 14.35 – 16.35 Oral Presentation (Room 1 – 3) and Poster Presentation (Room 4 – 6)

**Oral Presentation: Room 1**

**(Main Room) Public Health, Global Health, Health System Research, Health Care Management, Sustainable Development Goal, Communicable Diseases (CD) and Non-Communicable Diseases (NCD) Population, Demography, Aging and Migration**

*(10 minutes presentation 2 minutes Q&A)*

- Presentation 1.1:** Effectiveness of a Health Talk Education Program on Human Papillomavirus (HPV) Knowledge, Attitudes, and Intentions to Vaccinate Children Among Mothers of Secondary School Boys in Thua Thien Hue Province, Vietnam (OP1)  
**By** Duc Nguyen Minh
- Presentation 1.2:** G6PD Deficiency Found in Mixed Ethnic Community in Transmigration Area, Nimbokrang District Papua Indonesia (OP3)  
**By** Muhammad Fajri Rokhmad
- Presentation 1.3:** Implementing an Integrated Noncommunicable Disease Care Delivery with Primary Health Care in The Philippines: A qualitative case study (OP6)  
**By** TJ Robinson T. Moncatar
- Presentation 1.4:** Newly Proposed Communication Form for Pre-radiotherapy Dental Clearance of Chonburi Cancer Hospital Network (OP7)  
**By** Dr. Thanate Kamoldisai
- Presentation 1.5:** COVID-19 Vaccine Adherence and Behavioral Changes of Community People in the New Normal Context of the Coronavirus Pandemic (OP13)  
**By** Dr. Muhammed Ashraful Alam
- Presentation 1.6:** Knee Kinetics and Kinematics during Ten-Sao Dance: A Comparison between Khon Masked Dancers and Non-Dancers (OP23)  
**By** Pakamas Jearudomsup
- Presentation 1.7:** The Attitude towards Wife Beating: Do Young Men Act Differently? (OP24)  
**By** Desy Nuri Fajarningtiyas
- Presentation 1.8:** Adaptation of Sustainable Healthy Settlement to Social Cultural Life on Penyengat Island as a Cultural Reservation Area (OP26)  
**By** Indra Martias
- Presentation 1.9:** Evaluation of The Impact of The COVID-19 Pandemic and Epidemic Prevention Policies on Psychiatric Outpatients (OP27)  
**By** Chun-Ta Li
- Presentation 1.10:** Medical Treatment for Acid Attack Survivors: A Cure or a Burden? (OP28)  
**By** Lindawati  
**Chairperson:** Associate Professor Samuel Shih-Chih Wang, Ph.D.  
**Co-chairperson:** Mitoriana Porusia, SKM MSc  
**Committee:** Anchalee Prasansuklab, Ph.D.

**Oral Presentation: Room 2**

**Sexual and Reproductive Health, Gender and Sexuality, Violence Against Women and Children, STIs and HIV/AIDS, Health Behaviors, Substance abuse, Addiction studies, Mental Health, Health Promotion**

*(10 minutes presentation 2 minutes Q&A)*

- Presentation 2.1:** A Protocol Study: The Development and Psychometric Properties of Assessing Adolescent centered Internet Users Psychosocial and Occupational Performance (OP2)  
**By** Senthil Vadivel
- Presentation 2.2:** G6PD Deficiency Found in Mixed Ethnic Community in Transmigration Area, Nimbokrang District Papua Indonesia (OP3)  
**By** Muhammad Fajri Rokhmad
- Presentation 2.3:** Investigation of Cotinine Levels Among Thai Male Tobacco Farmers in Sukhothai Province, Thailand (OP5)  
**By** Anu Surach
- Presentation 2.4:** Mediation Effects of Premarital Sexual Permissiveness on The Relationship Between Expectations for Marriage and Marital Intention (OP10)  
**By** Nguyen Nguyen Trong
- Presentation 2.5:** Factors Associated with Complementary Feeding Practices Among Aged 6 to 23 Months Old Children in Cikarang Timur, Indonesia (OP11)  
**By** Ghina Nur Afra
- Presentation 2.6:** Epidemic Trend of Dengue Under High Awareness and Border Quarantine in Taiwan (OP16)  
**By** Yeong Ren Chen
- Presentation 2.7:** The Impact on Air Pollution by of Epidemic Prevention Policy of COVID-19 in Northern Taiwan (OP21)  
**By** Jia-Yi Lu
- Presentation 2.8:** The Effect of Covid-19 Prevention Policy on the Outpatient Visits of Depression Patients in Taipei of Taiwan (OP22)  
**By** Chia-Yu Chang
- Presentation 2.9:** Selfcare/Self-development Interventional Guidebook for Refugee Adolescents: Steps Toward a Comprehensive Intervention Development (OP29)  
**By** Dr. Marjan Mohammadzadeh
- Presentation 2.10:** Relationship between Gender Roles and Maternal Characteristics with Sexual Activity in Pregnancy at Sirampog Village, Brebes District, Central Java, Indonesia (OP30)  
**By** Evi Soviyti
- Presentation 2.11:** Dose the smokers quit smoking when the cigarette tax increased? (OP31)  
**By** Pei-Ching Chen  
**Chairperson:** Vinami Yulian, PhD  
**Co-chairperson:** Assistant Professor Tzu-Hsuen Yuan, Ph.D.  
**Committee:** Assistant Professor Tepanata Pumpaibool, Ph.D.

**Oral Presentation: Room 3**

**Universal Health Care Coverage, Social Security Scheme, Health Economic, Health Policy and Administration, One Health, Zoonoses and Antimicrobial Resistance, Environmental and Occupational Health, Workplace Hygiene and Safety, Global warming, Disaster management, Digital Health and Technology, Public Health Sciences**

*(10 minutes presentation 2 minutes Q&A)*

- Presentation 3.1:** Factors Associated with Food Safety Knowledge among Food Handlers in Surabaya Culinary Centers, Indonesia (OP8)  
**By** Pradevi Milafitri Farista Ananto
- Presentation 3.2:** The Clean and Healthy Behavior of Motorcycle online drivers in Samarinda, Indonesia (OP9)  
**By** Nur Rohmah
- Presentation 3.3:** Impact of Higher Education on The Compliance of Nepalese Physical Therapists with Knee Osteoarthritis Clinical Practice Guidelines (OP12)  
**By** Anuradha Shrestha
- Presentation 3.4:** Lower Extremity Kinematics and Kinetics During Walking: A Comparison between Khon Masked Dancers and Non-Dancers (OP14)  
**By** Zin Wai Htet
- Presentation 3.5:** Lumbar Multifidus Thickness is Associated with Lumbar Stability But Not Disability and Fear in Movement Control Impairment Subgroup of Chronic Low Back Pain (OP15)  
**By** Soniya Maharjan
- Presentation 3.6:** Machine Learning Algorithm-Driven Prediction System for Early Diagnosis of Nasopharyngeal Carcinoma Using Medical Claim Database (OP17)  
**By** Yu-Ning Chien
- Presentation 3.7:** Public Health Policies and Roles of Pharmacists in Pakistan (OP18)  
**By** Tawseef Ahmad
- Presentation 3.8:** Metformin Activity on Longevity and Mitochondrial Unfolded Protein Response (UPRmt) Across UPRmt Invoked C.elegans (OP19)  
**By** Anubhav Aryal
- Presentation 3.9:** Heavy Metals Contamination in Local White Rice: A Preliminary Study at Palembang, South Sumatra, Indonesia (OP20)  
**By** Dian Islamiati
- Presentation 3.10:** Effectiveness of Palliative Learning Model Based on Transformational Learning Theory on The Achievement of Nursing Student's Competency (OP25)  
**By** Ni Luh Putu Inca Buntari Agustini  
**Chairperson:** Assistant Professor Wan-Lin Chiang, Ph.D.  
**Co-chairperson:** Assistant Professor Dwi Rosella Komalasari, F.tr., M.Fis., Sp.Vest., Ph.D.  
**Committee:** Assistant Professor Anuchit Phanumartwiwath, Ph.D.
- 14.35 – 16.35** **Breakout Room 4-6: Poster Presentation**  
Coordinator: Assistant Professor Pokkate Wongsasuluk, Ph.D.  
Nuchanad Hounnaklang, Ph.D.  
Onuma Zongram, Ph.D.  
Narumol Bhummaphan, Ph.D.
- Committee: Senior Lecturers
- 16.35 – 17.00** Oral/Poster Presentation Outstanding Awards (Main Room) Closing Remarks  
**By** Professor Sathirakorn Pongpanich, Ph.D.  
Dean, College of Public Health Sciences, Chulalongkorn University  
MC: Assistant Professor Kraiwuth Kallawicha, Ph.D.  
Assistant Professor Wandee Sirichokchatchawan, Ph.D.



# Table of Contents

---

Preface.....	i
Welcome Message.....	ii
Organizers.....	v
Keynote Lectures	
<i>Topic I: Precision Public Health for a Resilient Society</i> .....	vii
<i>Topic II: Integrative Healthcare in Indonesia: Potencies and Challenges</i> .....	ix
<i>Topic III: Redirection of Public Health Education in a Changing World</i> .....	x
Conference Program.....	xi
Factors Associated with Behavior in the Prevention of Cardiovascular Complications in Hypertensive Patients in Indonesia: A Systematic Review	
<i>Israfil Israfil, Ah Yusuf, Ferry Efendi, Iskim Lutfa, Indah Sriwahyuningsih</i> .....	S1
A Review of Digitalization and Public Health: Potentials, Integrations and Impacts to the Malaysians Well-being	
<i>Nur Hazreen Mohd Hasni</i> .....	S9
Effectiveness of Telemedicine in Type 2 Diabetes Mellitus, Bueng Kan Hospital, Bueng Kan Province, Thailand	
<i>Kridsada Sirichaisit, Akaphol Kaladee, Warangkana Chankong</i> .....	S16
Effect of Adaptive Seating in Postural Control among Children with Cerebral Palsy: A Systematic Review	
<i>Bishnu Dutta Acharya, Saipin Prasertsukdee, Raweevan Lekskulchai, Prem Laxmi Baniya</i> .....	S24
The Clean and Healthy Behavior of Motorcycle Online Drivers in Samarinda, Indonesia	
<i>Nur Rohmah, Dina Lusiana Setyowati, Rina Tri Agustini</i> .....	S33
Level of Knowledge and Risk of osteoporosis and their association among Working Women Living in Klang Valley, Malaysia	
<i>Kye Mon Min Swe, Hnin Pwint Phyu, Kang Shu Ting, Wendy Lau Hui Ee, Hong Kai Xin, Alicia Ho Pei Shan, Tey Fu Hao</i> .....	S44
Lower Extremity Kinematics and Kinetics During Walking: A Comparison Between Khon Masked Dancers and Non-Dancers	
<i>Zin Wai Htet, Sunee Bovonsunthonchai, Pagamas Piriyaprasarth, Nopporn Jongkamonwiwat, Warin Kritiyakarana</i> .....	S52

# Table of Contents (Cont.)

---

## Impact of Measures on Reducing Cumulative Case Numbers of the First Wave of COVID-19 in Thailand

*Kanokkan Wongsawat, Patumrat Sripan, Pimwarat Srikummoon, Patrinee Traisathit, Pallop Siewchaisakul, Linda Aurpibul, Amarporn Rerkasem, Patcharaphan Sugandhavesa, Salinee Thumronglaohapun*.....S60

## Factors Associated with Complementary Feeding Practices among Mother of Aged 6 to 23 Months Old Children in Cikarang Timur, Indonesia

*Ghina Nur Afra, Wandee Sirichokchatchawan*.....S71

## Heavy Metals Contamination in Local White Rice: A Preliminary Study at Palembang, South Sumatra, Indonesia

*Dian Islamiati, Pokkate Wongsasuluk*.....S79

## Adaptation of Sustainable Healthy Settlement to Social-Cultural Life on Penyengat Island as a Cultural Reservation Area

*Indra Martias, Rifardi, Agrina, Imam Suprayogi, Syaza Halwa Amanina*.....S88

## Association of Multifidus Thickness with Disability, Lumbar Stability and Kinesiophobia in Movement Control Impairment Subgroup of Chronic Low Back Pain

*Soniya Maharjan, Khin Win Thu, Kanphajee Sornkaew, Sasithorn Konguon, Katayan Klahan, Peemongkon Wattananon*.....S94

## Newly Proposed Communication Form for Pre-radiotherapy Dental Clearance of Chonburi Cancer Hospital Network in Thailand

*Thanate Kamoladisai, Matana Pruksapong-Kettratad*.....S104

## Impact of Education on the Compliance of Nepalese Physical Therapists with Knee Osteoarthritis Clinical Practice Guidelines

*Anuradha Shrestha, Roongtiwa Vachalathiti, Sunee Bovonsunthonchai*.....S114

## Knee Kinetics and Kinematics during Ten-Sao Dance: A Comparison between Khon Masked Dancers and Non-dancers

*Pakamas Jearudomsup, Sunee Bovonsunthonchai, Roongtiwa Vachalathiti, Pagamas Piriyaprasarth, Warin Krityakiarana*.....S123

## Endotracheal Intubation in Patients with COVID-19 in Priest Hospital during COVID-19 Pandemic: A Retrospective Study

*Watchari Toni*.....S134

## Table of Contents (Cont.)

---

How COVID-19 Pandemic Affects Women's Fertility and Cross-Border  
Reproductive Care: A Taiwanese-Based Review

*Sun Chia-Ting*.....S139

Evaluation Research of the Measure to Monitor the Outbreak in Buntharik District,  
Ubon Ratchathani Province, Thailand to Control the Situation and  
Prevent the Spread of the Coronavirus Disease 2019

*Tanong Kamsri, Kopkan Choopan*.....S148

Factors Associated with Food Safety Knowledge among Food Handlers  
in Surabaya Culinary Centers, Indonesia

*Pradevi Milafitri Farista Ananto, Wandee Sirichokchatchawan*.....S158

Digital Literacy Skills among Village Health Volunteers in Pathumthani Province

*Supika Dangkrayang, Nathinee Phongphaitoonsin, Sawanee Tengrungsun,*

*Manida Manee-in, Alissa Ratanatawan*.....S167

Metformin Activity on Longevity and Mitochondrial Unfolded Protein Response (UPR<sup>mt</sup>)  
Across UPR<sup>mt</sup> Invoked *C. elegans*

*Anubhav Aryal, Chutipong Chiamkunakorn, Wichit Suthammarak*.....S176

Effectiveness of Palliative Learning Model Based on Transformational Learning Theory  
on the Achievement of Nursing Student' Competency

*Ni Luh Putu Inca Buntari Agustini, Nursalam Nursalam, Tintin Sukartini*.....S186



# Factors Associated with Behavior in the Prevention of Cardiovascular Complications in Hypertensive Patients in Indonesia: A Systematic Review

Israfil Israfil<sup>a, b</sup>, Ah Yusuf<sup>a, \*</sup>, Ferry Efendi<sup>a</sup>, Iskim Lutfu<sup>a, c</sup>,  
Indah Sriwahyuningsih<sup>a, c</sup>

<sup>a</sup> Faculty of Nursing, Universitas Airlangga, Surabaya, Indonesia

<sup>b</sup> Faculty of Health, Institute of Technology and Health Bali, Denpasar, Indonesia

<sup>c</sup> Faculty of Nursing, Sultan Agung Islamic University, Semarang, Indonesia

## Abstract

**Background:** Hypertension is known as a chronic non-communicable disease that can cause cardiovascular complications which are the main cause of patient death in the community. This study aims to synthesize research findings regarding factors related to behavior in the prevention of cardiovascular complications in hypertensive patients in Indonesia.

**Method:** A systematic review. The search strategy was conducted on the Indonesian national journal database, namely "Garuda" database and four international journal databases, namely Scopus, PubMed, Web of Science, and Science Direct with the keywords "hypertension" AND "complications" AND "Indonesia", and in the Indonesian national journal database it is written "komplikasi hipertensi". The inclusion criteria of the article were population: hypertensive patients in Indonesia, intervention: various factors related to cardiovascular complication prevention behavior, comparison: none, outcome: behavior to prevent complications, study design: RCT, quasi-experimental, cross-sectional, case-control. The published year is 2017-2022.

**Results:** There are 288 articles found in the search. Articles were identified and screened resulting in seven articles that met the inclusion criteria. The results of the study found that factors related to behavior for the prevention of cardiovascular complications in hypertensive patients were patient knowledge about hypertension, self-efficacy, and social support, namely family support and health worker support. Another factor that was also found was the individual's coping strategies in taking preventive measures to prevent cardiovascular complications.

**Conclusion:** Increasing knowledge can help lead to good behavior for the prevention of cardiovascular complications in hypertensive patients. Increasing health promotion needs to be done by involving the collaboration of health workers and families to support patients to produce healthy behaviors.

**Keywords:** Behavior, Cardiovascular, Hypertension, Indonesia

## 1. Introduction

Hypertension is one of the main factors causing the cardiovascular disease which is a serious health problem in developed and developing countries [1]. Hypertensive patients are at high risk for cardiovascular complications such as complications of non-hemorrhagic stroke (NHS), coronary artery disease (CHD), a combination

of NHS and CAD, and complications of angina pectoris [2]. Stroke and heart attack are types of cardiovascular complications in hypertensive patients which are the main causes of death in Indonesia [3].

The World Health Organization (WHO) in 2021 reported that cardiovascular disease (CVDs) is one of the leading causes of death in the world

\* Corresponding author.

E-mail address: ah-yusuf@fkip.unair.ac.id (Ah Yusuf)

globally. An estimated 17.9 million people died from cardiovascular disease in 2019 which represented 32% of all deaths worldwide. Heart attack and stroke are the most widely reported cardiovascular complications and are the main cause of death reaching 85% from cardiovascular disease [4]. In Indonesia, based on the results of the five-year National Health Research (Riskesmas) conducted by the Ministry of Health of the Republic of Indonesia in 2018 it was found that the prevalence of stroke increased from 7% in 2013 to 10.9% in 2018, the prevalence of heart disease was found to be 1, 5%. and the prevalence of hypertension which is a factor causing cardiovascular disease increased dramatically from 25.8% in 2013 to 34.1% in 2018 [5].

The prevalence of hypertension as a risk factor for cardiovascular disease in Indonesia has continued to increase in the last two decades. Some patients have been found to have uncontrolled blood pressure and an unhealthy lifestyle that exacerbates hypertension and increases the risk of cardiovascular complications [6]. Behaviors that are risk factors for cardiovascular complications in hypertensive patients in Indonesia are lack of fruit and vegetable consumption, lack of physical activity, consumption of salty foods, smoking, and harmful alcohol used [7-10], non-adherent behavior in taking hypertension medication, as well as non-health control behavior were also to be associated with the incidence of cardiovascular complications in hypertensive patients [2].

Recommendations for the behavioral prevention of cardiovascular complications in hypertensive patients are to improve hypertensive dietary behavior, manage body mass index, increase vigorous physical activity behavior, and monitor blood pressure behavior [9]. Recommendations are also given to hypertensive patients to behave obediently to the prescribed hypertension treatment therapy [2]. Unfortunately, the behavior for the prevention of cardiovascular complications as recommended is still not fully implemented by some hypertensive patients in Indonesia [7]. It is very important to identify the various factors that influence risky behavior for cardiovascular complications in hypertensive patients. This is

done so that in the future efforts to improve healthy behavior to prevent cardiovascular complications in hypertensive patients can be planned more optimally. The purpose of this study is to synthesize various research findings regarding factors that have been associated with cardiovascular complication prevention behavior in hypertensive patients in Indonesia.

## **2. Methods**

### *2.1. Study Design*

This study is a systematic review of the literature conducted to determine various factors related to behavior in preventing cardiovascular complications in hypertensive patients in Indonesia. The research was conducted with a systematic approach with a PRISMA literature study without conducting a meta-analysis test on quantitative data.

### *2.2. Search strategy*

The search for articles was carried out on the Indonesian national journal database, namely "Garuda" database and four international journal databases, namely Scopus, PubMed, Web of Science, and Science Direct. Search articles in international journal databases using the keywords "hypertension" AND "complications" AND "Indonesia", and in the database of Indonesian national journals it is written "komplikasi hipertensi"

### *2.3. Eligibility Criteria*

The articles used in the study were articles that met the PICOS inclusion criteria, namely the population: hypertensive patients in Indonesia, intervention; various factors related to cardiovascular complication prevention behavior, comparison: none, outcome: cardiovascular complication prevention behavior namely; dietary behavior, managing body mass index, physical activity, monitoring blood pressure, and adherence to prescribed hypertension medication therapy, study design: RCT, quasi-experimental, cross-sectional, case-control. The published year is 2017-2022. Article exclusion criteria were: not related to cardiovascular complications prevention behavior, non-hypertensive patient population,

review study design, published under 2017, article not published in a peer-reviewed journal.

2.4. Study selection

There were 288 articles found in the database search. There were 45 articles in the database of the national journal "Garuda" Indonesia, and 243 articles in the respective international journal databases, namely; Scopus 65, PubMed 10, Web of Science 18, and Science Direct 150. The researchers then filtered articles according to research objectives by deleting articles that were duplicates, identifying articles by title, identifying abstracts that match the inclusion criteria, and reading the full text of the relevant articles according to PICOS. The researcher

determined 7 relevant articles (Fig. 1).

2.5. Risk of bias

Assessment of article quality and risk of bias was carried out independently by the research team using JBI's critical assessment tool for analytical cross-sectional studies [11].

2.6. Data extraction

Articles that have been read in full are then structured and explored based on the name of the researcher, year of publication, research area, research design, sample, and research results, namely factors related to the behavior of preventing cardiovascular complications (Table 1).

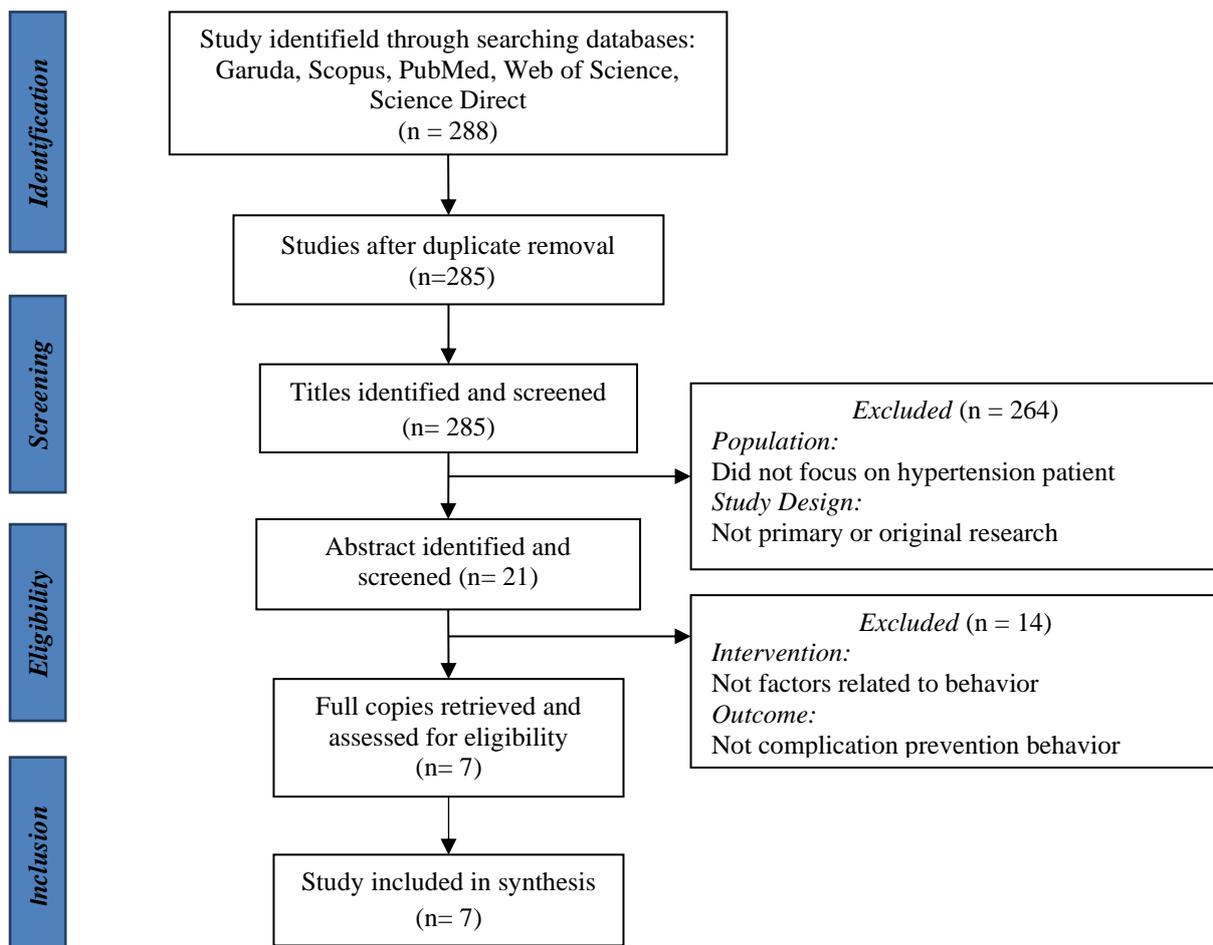


Fig.1. PRISMA flow diagram of the article selection process

*Table 1. Distribution of research results on factors related to the behavior of preventing cardiovascular complications in hypertensive patients in Indonesia.*

<b>Researcher</b>	<b>Research Area</b>	<b>Research design</b>	<b>Sample</b>	<b>Data Analysis</b>	<b>Research results; factors related to complications prevention behavior</b>
Fikriana et al. [12]	Malang city. East Java Province	Cross sectional	108 hypertensive patients (84,3% female, 46,3% no schooling)	Multiple linear regression  Significance Level= 0.05	Active coping, planning, suppression of competitive activities, self-control, and social support
Sulastris et al. [1]	Luwu Regency, South Sulawesi Province	Cross sectional	70 hypertensive patients (67,1% female, 37,1% senior high school)	Gamma Test  Significance Level= 0.05	Knowledge about hypertension
Upoyo et al. [3]	Banyumas Regency, Central of Java Province	Cross sectional	461 hypertensive patients (80,9% female, 70,9% elementary school)	Chi-square and logistic regression  Significance Level= 0.05	Self-efficacy, perception, and awareness of stroke risk.
Giena et al. [13]	Bengkulu City, Bengkulu Province	Cross sectional	333 hypertensive patients (59,8% female, 37,2% primary high school)	Multiple linear regression  Significance Level= 0.05	Level of education, knowledge, self-efficacy, perceived barriers, social support, situational influence
Rozi et al. [14]	Surabaya City, East Java Province	Cross sectional	272 hypertensive patients (66% female, 45% senior high school)	Spearman rank  Significance Level= 0.05	Knowledge about hypertension
Mujiran et al. [15]	Karanganyar Regency, Central Java Province	Cross sectional	55 hypertensive patients (58,2% female, 43,6% elementary school)	Gamma test  Significance Level= 0.05	Knowledge about hypertension
Abdu [16]	Makassar City, South Sulawesi Province	Cross sectional	40 hypertensive patients (62,6% female, 27,5% junior high school)	Chi Square  Significance Level= 0.05	Knowledge about hypertension

### 3. Results

#### 3.1. Characteristic study

The seven articles that have been synthesized are all original research with a cross-sectional study design. A total of 4 articles are the result of research that has been carried out on the island of Java, 2 articles are the result of research that has been carried out on the island of Sulawesi, and 1 article is the result of research that has been carried out on the island of Sumatra. The total hypertensive patients involved in all these studies were 1,339 people. As many as 916 out of 1,339 (68.4%) patients were female, with the highest level of education from all the results of the study being senior high school education.

#### 3.2. Outcomes

The outcomes of the analysis found that the factors related to the behavior of preventing cardiovascular complications in hypertensive patients based on the results of existing research were the patient's knowledge of hypertension, self-efficacy of hypertensive patients, and social support, namely family support and health worker support. Another factor that was also found was the coping strategy (Table 1).

### 4. Discussion

This study found that factors related to behavior in preventing cardiovascular complications in hypertensive patients were patient knowledge about hypertension, self-efficacy of hypertensive patients, and social support, namely family and health worker support. Another factor that was also found was coping strategy.

Knowledge about hypertension was obtained as a predictor related to health behavior in hypertensive patients [13]. Patient knowledge about hypertension has a significant relationship with complication-prevention behavior [1, 14-16]. Good knowledge about hypertension can increase patient awareness of the health problems experienced so that complication-prevention behavior can be carried out [16]. Hypertensive sufferers sometimes do not realize that they have hypertension and only find out when experiencing several complaints that have become complications [1]. Knowledge is the

domain of behavior related to the prevention of complications in hypertensive patients. Hypertensive patients who have good knowledge are better able to regulate their lifestyle and patterns as evidenced by the majority of respondents in the study having good behavior in preventing hypertension complications [14].

Patient knowledge about hypertension is influenced by various factors such as education level, length of suffering from hypertension, and sources of information obtained [16]. Education level is positively correlated with health-related behaviors. Patients with higher education levels are aware of their health behavior and seek information about their health conditions [13]. The level of education also affects the patient's ability to access and understand information about hypertension. The higher the level of education, the better the patient in accessing information, receiving information and interpreting any information obtained [16]. Most patients know information about hypertension directly from health workers [14]. Information about hypertension is also obtained from various sources, both from health workers, print media, and electronic media [16].

Self-efficacy was found to be one of the strongest predictors of the health behavior of hypertensive patients [13]. Factors related to the behavior of preventing stroke complications in hypertensive patients are self-efficacy, perception, and awareness of stroke risk [3]. Self-efficacy is the patient's confidence in his ability to take steps to prevent complications of hypertension. Increased self-efficacy results in an increase in health promotion behavior that is better for preventing cardiovascular complications in hypertensive patients. Self-efficacy can directly motivate patients to adopt appropriate health behaviors. Patients who have confidence that hypertension can be controlled will be able to carry out the recommended complication prevention behaviors and are likely to be able to do it effectively and improve [13]. Self-efficacy is an important indicator to obtain better self-management of hypertensive patients. Self-efficacy was found to be a determinant of the success of smoking cessation behavior, increased

physical activity, and adherence to a healthy diet in hypertensive patients [3]. Self-efficacy in hypertensive patients is influenced by various factors including education level, work history, and spiritual activity [17]. The level of education contributes to the patient's understanding of health information and health literacy, and work history has a physiological impact on the patient's current physical health which has an effect on disease severity and affects self-efficacy, and spiritual activity with worship activities according to the patient's religion and beliefs affect mental well-being and quality. patient's life in preventing complications of hypertension. In addition, self-efficacy related to the daily activities of hypertensive patients is the risk of falls, pain, depression, anxiety, and stress [17].

Social support is a patient's interpersonal relationship with others that is positively correlated and becomes a strong predictor of health behavior [13]. Social support allows patients to get more information, advice, and emotional comfort about the health problems they face. Good social support will provide a lot of positive information that can reduce anxiety in hypertensive patients so that they can control blood pressure and avoid the risk of complications [12]. Social support was also found to influence the behavior of hypertensive patients taking antihypertensive drugs to prevent cardiovascular complications [18].

Social support is the use of supporting resources from other people such as family, friends, or other important people [13]. Situational influences and support from family and friends can influence the efforts of hypertensive patients to improve better health behavior [1]. Positive family social support will result in good family attitudes and abilities in maintaining and caring for family members who suffer from hypertension. Family social support can improve the quality of life of hypertensive patients to avoid the risk of further complications. The results showed that there was an effect of family attitudes on preventing complications in hypertension patients [19]. The role of family health assistants has a significant relationship with the incidence of complications in

hypertensive patients [20]. The social support of health workers as important people in health care for hypertensive patients also has a positive influence on the behavior of preventing complications in hypertensive patients. Patients always interact with health workers in the treatment room, especially with nurses and doctors who provide services. The more often the patient interacts socially with health workers, the more often the patient is exposed to appropriate health education so that the behavior of preventing hypertension complications can be improved [16].

Coping strategies were found to have a significant relationship with anxiety which is one of the risk factors for causing complications in hypertensive patients [12]. Anxiety is a negative behavior that is a psychological response to fear or worry that occurs due to changes in health status in hypertensive patients. Anxiety or stress are both conditions of emotional tension due to worries or fears that are felt continuously which can increase blood pressure or hypertension and can trigger complications of stroke and heart attack in hypertensive patients [21].

Conditions that can reduce anxiety levels in hypertensive patients are active coping strategies, planning, suppression of opposing activities, self-control, and the use of social support. Active coping is a wise action taken by hypertensive patients in dealing with problems by remaining calm. The higher the patient's active coping, the less anxiety experienced. Planning can increase the patient's readiness to improve their behavior of preventing cardiovascular complications. Good planning will increase the value of the patient's reactive and proactive cognition so that the level of anxiety or worry about hypertension complications can be reduced. Emphasis on competitive activities is the patient's effort to focus on solving health problems that are experienced by him and putting aside other things that are not important. This condition can help hypertensive patients gain emotional stability so that the risk of complications can be avoided. Self-control is a patient's effort to refrain from taking actions or behaviors that are at risk of causing complications [12]. Individual coping of

hypertensive patients includes the patient's perception and awareness of the risk of complications [3].

## 5. Conclusion

The behavior of preventing cardiovascular complications in hypertensive patients is related to the patient's level of knowledge about hypertension, self-efficacy, and social support, namely family support, and health worker support. Another factor that was also found was the individual coping strategy of hypertensive patients in preventing cardiovascular complications. Health promotion about the dangers of cardiovascular complications in hypertensive patients must continue to be improved. Collaboration between health workers and patient families is important to be selected to improve the behavior of hypertensive patients to be healthier.

## Study Limitations

We realize that this study has limitations. The number of articles found and synthesized in this study is still limited from a few regions. But at least, the results of this study help us find some research evidence on factors that have been associated with the behavior of hypertensive patients in preventing cardiovascular complications in the community.

## Conflict of Interest

The authors declare that there is no conflict of interest in the publication of this paper.

## References

- [1] Sulastris SN, Hidayat W, Lindriani. Hubungan Tingkat Pengetahuan tentang Hipertensi dengan Perilaku Pencegahan Terjadinya Komplikasi Hipertensi. *Jurnal Keperawatan Florence Nightingale*. 2021; 4(2): 89-93. doi: 10.52774/jkfn.v4i2.78
- [2] Israfil, Making MA. Blood glucose level, blood pressure, and medication behavior are related to cardiovascular complication in hypertension patient at Sikumana Public Health Center. *Unnes J Public Health*. 2020; 9(1): 50-5. doi: 10.15294/ujph.v9i1.28051
- [3] Upoyo AS, Isworo A, Sari Y, Taufik A, Sumeru A, Anam A. Determinant Factors stroke prevention behavior among hypertension patient in Indonesia. *Open Access Maced J Med Sci*. 2021; 9(E): 336-9. doi: 10.3889/oamjms.2021.6040
- [4] World Health Organization [WHO]. Cardiovascular diseases 2021. Available from: [https://www.who.int/health-topics/cardiovascular-diseases#tab=tab\\_1](https://www.who.int/health-topics/cardiovascular-diseases#tab=tab_1)
- [5] Kemenkes RI. Hasil Utama Riskesdas Tahun 2018. Kementerian Kesehatan Badan Penelitian dan Pengembangan Kesehatan. Available from: <https://ners.unair.ac.id/site/index.php/program-studi/program-studi-doktor-keperawatan>
- [6] Sulistiawati S, Dewanti L, Pratama AP, Atika A, Fatmaningrum W, Nuswantoro D, et al. Profile and lifestyle of hypertensive patients, cardiovascular comorbidity, and complications in a primary health center in Surabaya, Indonesia. *Open Access Maced J Med Sci*. 2020; 8: 219-23. doi: 10.3889/oamjms.2020.4432
- [7] Kemenkes RI. Hipertensi Si Pembunuh Senyap. Kementerian Kesehatan RI. Available from: <https://pusdatin.kemkes.go.id/resources/download/pusdatin/infodatin/infodatin-hipertensi-si-pembunuh-senyap.pdf>
- [8] World Health Organization [WHO]. Cardiovascular Diseases (CVDs). Available from: [https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-\(cvds\)](https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds))
- [9] Isaura ER, Chen YC, Yang SH. Pathways from food consumption score to cardiovascular disease: a seven-year follow-up study of Indonesian adults. *Int J Environ Res Public Health*. 2018; 15(8). doi: 10.3390/ijerph15081567
- [10] Syarfaini, Nildawati, Aeni S, Surahmawati, Adha AS, Amansyah M. Risk factors preparation of stroke incidence in health institution employees who check up at the Health Service EXPO Event Indonesia. *Gac Sanit*. 2021; 35(Suppl 1): S49-52. doi: 10.1016/j.gaceta.2020.12.014
- [11] Moola S. Checklist for analytical cross sectional studies. Joanna Briggs Institute Reviewer's Manual. Available from: <http://joannabriggs.org/research/critical-appraisal-tools>
- [12] Fikriana R, Nurbadriyah WD, Tri N. The correlation between coping strategies and anxiety in hypertension patients in Malang Regency, Indonesia. *Stud Ethno-med*. 2022; 16(1-2): 37-42. doi: 10.31901/24566772.2022/16.1-2.638
- [13] Gienna VP, Thongpat S, Nitirat P. Predictors of

- health-promoting behaviour among older adults with hypertension in Indonesia. *Int J Nurs Sci*. 2018; 5(2): 201-5. doi: 10.1016/j.ijnss.2018.04.002
- [14] Rozi F, Zatihulwani EZ, Sari GM. Determinan Faktor yang Berhubungan dengan Prilaku Pencegahan Komplikasi pada Hipertensi. *Jurnal Penelitian Kesehatan Suara Forikes*. 2021; 12: 126-9.
- [15] Mujiran, Setiyawan, Rizqie NS. Relationship of the level of knowledge about hypertension with attitude in the prevention of complication of hypertension in elderly participants PROLANIS Public Health Center Jenawi Karanganyar. *PLACENTUM Jurnal Ilmiah Kesehatan dan Aplikasinya*. 2019; 7(2): 34-41. doi: 10.20961/placentum.v7i2.29734
- [16] Abdu S. Analisis Pengetahuan Klien Hipertensi Dengan Perilaku Pencegahan Komplikasi Hipertensi. *Jurnal Keperawatan Florence Nightingale*. 2018; 1(1): 20-30
- [17] Susanto T, Rasny H, Susumaningrum AL, Yunanto AR, Nur MKR. Prevalence of hypertension and predictive factors of self-efficacy among elderly people with hypertension in institutional-based rehabilitation in Indonesia. *Kontak*. 2019; 21(1): 14-21. doi: 10.32725/kont.2018.007
- [18] Rahmawati R, Bajorek B. Understanding untreated hypertension from patients' point of view: A qualitative study in rural Yogyakarta province, Indonesia. *Chronic Illn*. 2018; 14(3): 228-40. doi: 10.1177/1742395317718034
- [19] Karyawanto, Agata A, Arif A Al. Pengaruh sikap keluarga terhadap pencegahan komplikasi hipertensi grade II sebelum dan sesudah dilakukan pendidikan kesehatan. *J Ilmu Keperawatan Indones*. 2021; 2(2): 1-8.
- [20] Israfil I, Sinaga M, Ludji IDR. Effect of patients behavior and family health companion role on hypertension complication occurrence. *Unnes J Public Healh*. 2018; 7(2): 133-41. doi: 10.15294/ujph.v7i2.20982
- [21] Wekesah FM, Kyobutungi C, Grobbee DE, Klipstein-Grobusch K. Understanding of and perceptions towards cardiovascular diseases and their risk factors: a qualitative study among residents of urban informal settings in Nairobi. *BMJ Open*. 2019; 9(6): e026852. doi: 10.1136/bmjopen-2018-026852

# A Review of Digitalization and Public Health: Potentials, Integrations and Impacts to the Malaysians Well-being

Nur Hazreen Mohd Hasni \*

Family Health Unit, Jabatan Kesihatan Negeri Pahang, Malaysia

## Abstract

**Background:** Malaysia currently in the era of digital transformation aimed to develop a sustainable digital government, adoption of emerging digital technologies, and implement a strategy between the public sector and other agencies. Due to the rapidly emerging digitalization, author had interest in understanding of the potential of public health digitalization; the integration strategy of digital transformation in the health system; and the impact of digitalization on public health sector particularly for the well-being of Malaysian.

**Method:** A comprehensive search of peer-reviewed journals, conference papers or reports, was completed based on wide range of key terms including digitalization, public health digitalization, and digitalization in Malaysia. The search process through Google Scholar uncovered 12 peer-reviewed articles published and additional 15 reports and websites articles.

**Results:** The booming digital market has great potential to improve health care and enhance health literature among Malaysians. Besides, promote patients' empowerment in monitoring health status, facilitate during infectious disease outbreak management. In strengthening the health system, three main actors in digitalization include stakeholders, digital entrepreneurs, and digital tools users. Digitalization act as a game-changer for Malaysian well-being. Appropriate use of digital technologies promotes a sustainable digital health ecosystem. Nonetheless, digitalization may cause exacerbation of health disparities as well. Several impacts including discrimination; breaches of privacy; iatrogenesis; disinformation and misinformation and cyber-attacks may exist. Besides, digitalization will benefit individual's wealth status and literature level if commencing digitalization in education and economic.

**Conclusion:** The well-being of Malaysian was guaranteed with the establishment of MyDIGITAL, Public Sector Digitalization Strategic Plan 2020-2025 and Malaysian Ministry of Health Digitalization Strategic Plan 2021-2025. A strategic approach among key players involving multi-stakeholders, healthcare workers, and digital businesses may balance the impact of digitalization. Study suggest, by speeding up the integration process of digital tools and technologies promises a transformation of Malaysian health system.

**Keywords:** Public health digitalization, Well-being, Malaysia

## 1. Introduction

Malaysia currently in the era of digital transformation aimed to develop a sustainable digital government, adoption of emerging digital technologies, and implement a strategy between the public sector and other agencies. In 2020, 60% of the world's total population was using the internet, despite only 49% in 2018. The

percentage difference has been observed in ASEAN countries' populations such as Thailand, Indonesia, and Singapore are 21%, 14%, and 4% respectively [1]. In Malaysia, an identical landscape has been reported. Between 2020 and 2021, the percentage difference between internet users was 7.2%, mobile phone users 0.5%, and computer users 3.5% [2].

---

\* Corresponding author.

E-mail address: drhazreen@gmail.com (Nur Hazreen Mohd Hasni)

COVID-19 brought us a catastrophic life event however some wisdom was revealed. The rapidly increase numbers of internet users and digital tools users within the last two years hypothetically were due to the COVID-19 pandemic. International Health Regulations emphasize all countries have a core capacity to ensure national preparedness for infectious hazards that have the potential to spread internationally [3]. Therefore, the implementation of Movement Control Orders (MCO) and the interruption of individual mobilization were the strongly driven factors for skyrocketed numbers of internet users and digital tools users [3, 4].

The most popular activities of Malaysian have been reported between 2020 and 2021 were social networking 98%, media downloading 87%, good and services information-seeking 85%, internet telephoning 81%, and software and applications downloading 78% [4]. Increased demand for internet and digital tools usage creating opportunities for digitalization in various sectors such as education, business, and public health as well. Virtual dating, cloud meeting and video conferences allowing peoples to continue daily life as a human being.

The term 'digital' and 'digitalization' were commonly used interchangeably. From a further research, the word 'digital' refers to using data in the form of numerical digits [5]. Whereas 'digitalization' refers to the process of integrating the digital technologies into a business model and providing new revenue and value-producing opportunities. The ongoing 4<sup>th</sup> Industrial Revolution (IR4.0) initiates the shift from mechanical and analogue technology to digital technology [6]. Malaysia is currently in an early phase of the digital transformation era. MyDIGITAL initiative was developed in 2021, and may benefit the community, entrepreneur, and government; by strengthening the digital foundation; driving a digital transformation across the community and entrepreneurs, and positioning Malaysia as a digital producer and digital provider [7]. This initiative has been adopted by all public sectors per Sustainable Development Goal 2030 (SDG-11, SDG-16) and The Twelfth Malaysia Plan 2020-2025

(*Rancangan Malaysia Kedua Belas 2020-2025*). Malaysian Government aimed to develop a sustainable digital government, adoption of emerging digital technologies, and implement a strategy between the public sector and other agencies [8]. With these strategic plans, author believes that Government of Malaysia particularly the public health sector will extra stronger and ready to start a digitalization networking with other agencies.

Many had queried the urgency of digital transformation in public health system particularly in Malaysia. Due to the vast nature of the digital landscape and rapidly emerging digitalization in the public sector, this article will provide an understanding of the potential of public health digitalization; the integration strategy of digital transformation in the health system; and the impact of digitalization on public health sector particularly for the well-being of Malaysian.

## 2. Methods

Several procedures were followed to ensure a high-quality review of the literature on websites and journals. First, a comprehensive search of peer-reviewed journals, conference papers or reports, was completed based on wide range of key terms including digitalization, public health digitalization, and digitalization in Malaysia. All database was searched using the Google Scholar. Second, the reference section for each article found was searched in order to find additional articles. The search process uncovered 12 peer-reviewed articles published and additional 15 mixed reports and websites articles. Fig. 1 summarized a flow for reviews of Digitalization and Public Health in Malaysia according to PRISMA 2020 [9].

## 3. Results

### 3.1. Potentials of Digitalization

Acknowledging that digitalization permeates all in communities, healthcare workers, and health systems. The booming digital market has great potential to improve health care [10]. For instance, mobile apps enable the community to identify health risks, monitor wellness, track blood sugar levels, or record blood pressure [11].

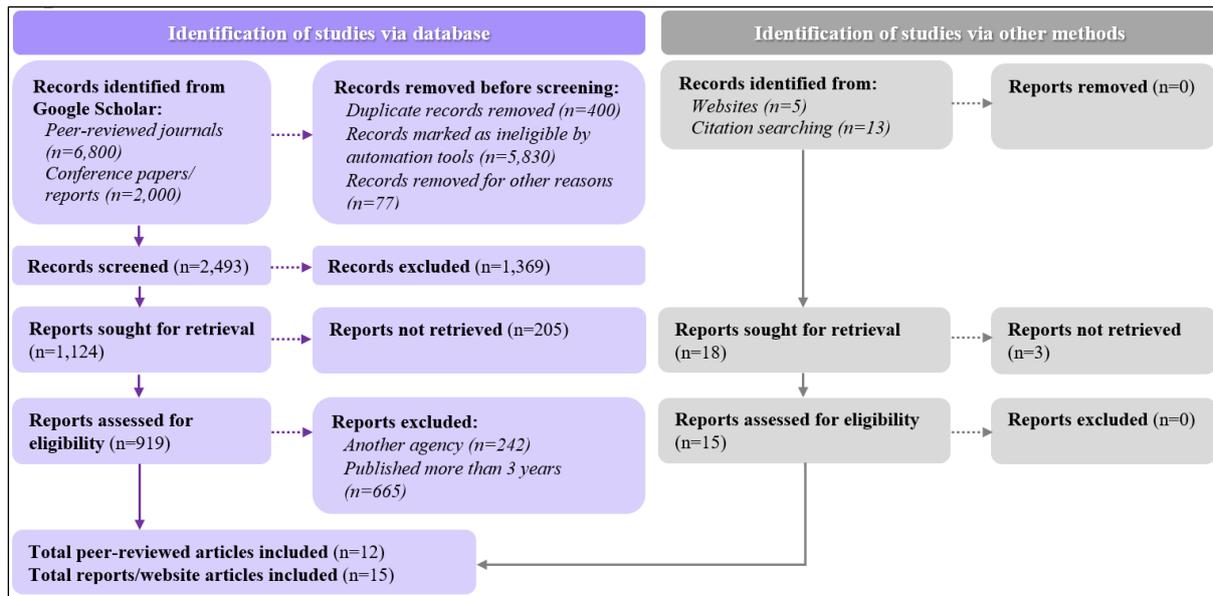


Fig. 1. Flow diagram for reviews of Digitalization and Public Health in Malaysia.

Digitalization also has the potential to enhance health literature among Malaysians. By using a smartphone, individuals can seek health information, contact a doctor or establish personalized coaching through virtual consultations [11, 12]. In addition, digitalization has the potential to promote patients' empowerment. Digital devices allow patients to generate, monitor, or interpret their health data. Internet and social media introduced interaction among users [12], thus bolstering health communication.

Digitalization of public health should be considered in a broader value chain in expediting patient management. The existing system facilitates patient management such as Patient Management System (*Sistem Pengurusan Pesakit, SPP*), Critical Care Information System (CCIS), Hospital Information System (HIS). Digital transformation has the potential to facilitate infectious disease outbreak management. The most popular app during the COVID-19 pandemic, MySejahtera, eases healthcare workers to do a risk assessment, contact tracing, declaration of House Surveillance Order (HSO), and monitor health status [13]. Moreover, digitalization allows healthcare professionals to upgrade skills virtually via

personalized training or in a group [14]. Social media offer healthcare workers a platform for gearing health promotion [15]. Healthcare researchers were able to develop a novel digital health intervention [16]. The rapidly shared health information and data collection using digital applications facilitate digital health research [17]. Digital Health Research & Innovation Unit (DHRi) was established by Malaysia Institute for Clinical Research which is concerned with digital health research.

Digitalization has the potential in strengthening the health system. Electronic health records data can largely support automatic reporting to public health agencies on notifiable diseases and chronic conditions [12]. Furthermore, digitalization convinced the Malaysian health system to achieve a sustainable health system by increasing process efficiency, improving medical quality as well as patient safety [18]. Digitalization offer cost-effective settings as well. For example, e-consultation and telemonitoring are worthwhile compared to the existing healthcare systems [19].

### 3.2. Integration Strategies of Digitalization

Integration strategies of digital transformation in the health system involved three main actors

include stakeholders, digital entrepreneurs, and digital tools users. Political commitment should be translated into normative and regulatory frameworks. Digitalization Strategic Plan of the Ministry of Health Malaysia 2021-2025 (*Pelan Strategik Pendigitalan Kementerian Kesihatan Malaysia 2021-2025*) aimed for the better health of communities and to ensure high quality of the public health system by emphasizing professionalism, teamwork, respect, and community engagement. This initiative involved stakeholders from various agencies and the committee highlighted the core issues including political commitment, established a regulatory framework, discussing the technical infrastructure and economic investment for digitalization in the public health sector [14].

Digital entrepreneur plays a role to integrates digital innovations into the health system. Technologists, digital researchers, and digital providers should excel in research and development [12]. Expectations were high impact digital product, high efficacy digital devices, and cost-effective for users and the health system. For example, information technologist has developed the *Infosihat* portal and MyHEALTH portal for Malaysians to gain health information. Teleprimary Care System (TPC) and Teleprimary Care – Oral Health Clinical Information System (TPC-OHCIS) have been developed to facilitate the patients' management in the health facility. eCOVID-19 System and the Public Health Laboratory Information System (*Sistem Informasi Makmal Kesihatan Awam, SIMKA*) has been developed during the pandemic to open doors for physician in managing COVID-19 cases [14].

Digital tools' users may be healthcare workers, communities, or individuals. Cultivating a culture of learning about digital tools and digital systems may promote digital transformation in the health system. Openness for collaboration with digital industries will ensure the continuous transformation of the health system [20]. Community health education by promoting digital technology in their daily life will improve work efficiency and improve community awareness [21]. *MyNutriDiari 2* and *MySihat*

Online Evaluation System (MOVes) has been developed to empower Malaysian community involvement [14]. Digital health supports a shift from cure to prevention both for primary and secondary prevention.

### 3.3. Impacts of Digitalization

Digitalization is a game-changer for Malaysian well-being. The impact of transferring knowledge and information sharing amongst disparate communities was visible [22]. Appropriate use of digital technologies gives an impact on community safety, economy, effectiveness, and efficiency for the communities, therefore can achieve a sustainable digital health ecosystem [23].

Nonetheless, digitalization may cause exacerbation of health disparities. According to a household survey in 2019, mobile broadband users in rural 80%, urban 88%. Whereas for the fixed broadband user in rural 11%, urban 35% [4]. The possibility to access health information or self-monitoring through mobile apps is nearly impossible. However, reshaping of digital infrastructure has been outlined by the government and rural communities may get a benefit [7]. The unevenness of digital technologies' implications was some may tailor technologies while others need to adapt with technologies [24]. This might promote undesired implications of technologies and might create a big gap in patient care. Therefore, aim to reduce bridging gaps in knowledge and flow of information by facilitating communication and knowledge across the different levels in the organization [25].

## 4. Discussion

There were some concerns in some cases. Whether Ministry of Health (MoH) Malaysia has the capacity for digital transformation. With full support from the Government of Malaysia, the digital transformation of the health system will be feasible [7]. Several attentions need to be addressed such as discrimination; breaches of privacy; iatrogenesis; disinformation and misinformation and cyber-attacks [26]. The National Cyber Security Agency (NACSA) expert in cyber security and is committed to securing and

strengthening Malaysia's resilience in facing cyber-attacks.

Besides, digitalization in other sectors such as education and business give an impact on public health. For example, BMI, obesity, and overweight increased among children during the COVID-19 lockdown [27]. Therefore, digitalization in education increases the non-communicable disease (NCD) burden and gives an impact on public health. Another example, engaging with social media platforms can create potential situations where individuals may be victimized by negative comments. Cyberbullying may cause impact mental health and may cause depression or anxiety [28]. Community with less engagement with social media may experience a better life.

**5. Conclusion**

In conclusion, digitalization and public health have much potential for the state of health for individuals and the community. The well-being of Malaysian was guaranteed with the establishment of MyDIGITAL, Public Sector Digitalization Strategic Plan 2020-2025 (*Pelan Strategik Pendigitalan Sektor Awam 2020-2025*) and Malaysian Ministry of Health Digitalization Strategic Plan 2021-2025 (*Pelan Strategik Pendigitalan Kementerian Kesihatan Malaysia 2021-2025*). The integration of digital tools and technologies into the health system ensures the quality of care thus strengthening the health system in Malaysia. The negative impact and positive impact of digitalization in public health can be balanced through a strategic approach among key players involving multi-stakeholders, healthcare workers, and digital businesses. Fig. 2 summarize the potentials, integrations and impacts of public health digitalization in Malaysia.

**Recommendations**

The implementation of MyDIGITAL, Public Sector Digitalization Strategic Plan 2020-2025 (*Pelan Strategik Pendigitalan Sektor Awam 2020-2025*) and Malaysian Ministry of Health Digitalization Strategic Plan 2021-2025 (*Pelan Strategik Pendigitalan Kementerian Kesihatan*

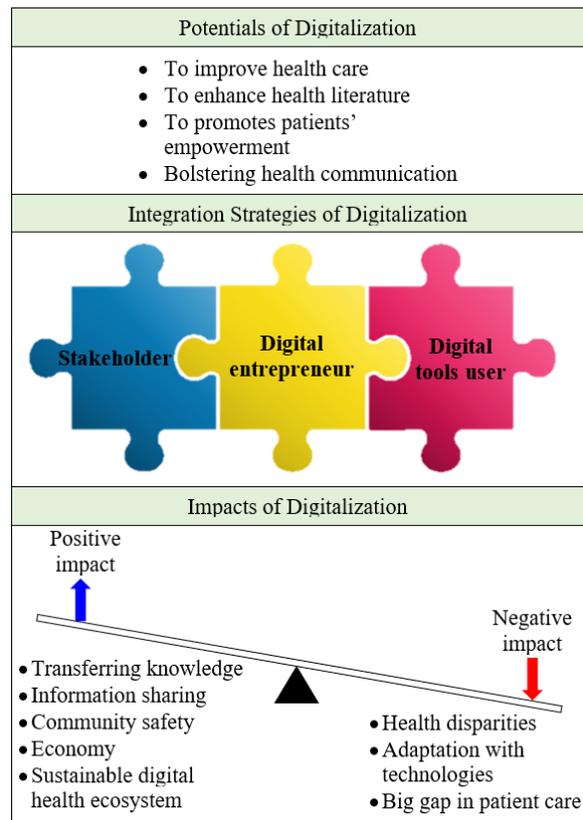


Fig. 2. The potentials, integration and impacts of public health digitalization in Malaysia.

Malaysia 2021-2025) accordingly will promotes the well-being of Malaysian. Speeding up the integration process of digital tools and technologies promises a transformation of Malaysian health system. The slogan of “Health for All” can be achieved through balanced and dynamic approach among key players.

**Acknowledgements**

This paper would not have been possible without the exceptional support from my colleague, Latifatul Nur Ahmad Hanbali from Jabatan Kesihatan Negeri Pahang. Her willingness to looked over the manuscripts and unexpectedly shared the invaluable information. Tremendous thanks to Associate Professor Ts. Dr. Mohd Azrul Hisham Bin Mohd Adib from Medical Device and Health Intervention Team (MeDeHIT), Universiti Malaysia Pahang for assistance in constructing the idea on the manuscript.

## References

- [1] World Bank. Data: individuals using the internet (% of population). [cited 2022 Jun 13]. Available from: <https://data.worldbank.org/indicator/IT.NET.USER.ZS>
- [2] Department of Statistic Malaysia. ICT use and access by individuals and household survey report 2021. [updated 2022 Apr 28; cited 2022 Jun 13]. Available from: [https://www.dosm.gov.my/v1/index.php?r=column/cthemByCat&cat=395&bu1\\_id=bCs4UINSQktybTR3THZ3a0RzV2RkUT09&menu\\_id=amVoWU54UTI0a21NWmdhMjFMMWcyZz09](https://www.dosm.gov.my/v1/index.php?r=column/cthemByCat&cat=395&bu1_id=bCs4UINSQktybTR3THZ3a0RzV2RkUT09&menu_id=amVoWU54UTI0a21NWmdhMjFMMWcyZz09)
- [3] Budd J, Miller BS, Manning EM, Lamos V, Zhuang M, Edelstein M, et al. Digital technologies in the public-health response to COVID-19. *Nat Med.* 2020; 26(8): 1183-92. doi: 10.1038/s41591-020-1011-4
- [4] Malaysian Communications and Multimedia Commission [MCMC]. Internet users survey 2020. MCMC; 2020.
- [5] Dictionary.com. Digital. [cited 2022 Jun 13]. Available from: <https://www.dictionary.com/browse/digital>
- [6] Information Technology Gartner Glossary. Digitalization. [cited 2022 Jun 13]. Available from: <https://www.gartner.com/en/information-technology/glossary/digitalization>
- [7] Jabatan Perdana Menteri. Rangka tindakan (blueprint) ekonomi digital Malaysia (MyDIGITAL). Putrajaya: Federal Government Administrative Centre; 2021.
- [8] Malaysian Administrative Modernisation and Management Planning Unit [MAMPU]. Ringkasan eksekutif: pelan strategik pendigitalan sektor awam 2021-2025. MAMPU; 2021.
- [9] Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ.* 2021; 372: n71. doi: 10.1136/bmj.n71
- [10] Rigamonti L, Albrecht UV, Lutter C, Tempel M, Wolfarth B, Back DA, et al. Potentials of Digitalization in Sports Medicine: A Narrative Review. *Curr Sports Med Rep.* 2020; 19(4): 157-63. doi: 10.1249/JSR.0000000000000704
- [11] Blix M, Levay C. Digitalization and health care - a report to the Swedish government's expert group on public economics. The Expert Group on Public Economics; 2018.
- [12] Odone A, Buttigieg S, Ricciardi W, Azzopardi-Muscat N, Staines A. Public health digitalization in Europe. *Eur J Public Health.* 2019; 29(Suppl 3): 28-35. doi: 10.1093/eurpub/ckz161
- [13] MySejahtera. FAQ MySejahtera. [cited 2022 Jun 16]. Available from: [https://mysejahtera.malaysia.gov.my/faq\\_en/](https://mysejahtera.malaysia.gov.my/faq_en/)
- [14] Kementerian Kesihatan Malaysia. Pelan strategik pendigitalan Kementerian Kesihatan Malaysia 2021-2025. Kementerian Kesihatan Malaysia; 2022.
- [15] Koh A, Swanepoel W, Ling A, Ho BL, Tan SY, Lim J. Digital health promotion: promise and peril. *Health Promot Int.* 2021; 36(Suppl 1): i70-i80. doi: 10.1093/heapro/daab134
- [16] World Health Organization [WHO]. Classification of digital health interventions v1.0: a shared language to describe the uses of digital technology for health. [cited 2022 Jun 15]. Available from: <https://apps.who.int/iris/handle/10665/260480>
- [17] World Health Organization [WHO]. WHO guideline: recommendations on digital interventions for health system strengthening. Geneva: WHO; 2019.
- [18] von Eiff M, von Eiff W. The digitalisation of healthcare. *HealthManagement.org The Journal.* 2020; 20(2): 182-7.
- [19] Brucher L, Pontet K, Mosel K, Georges A. A journey towards smart health: the impact of digitalization on patient experience. Deloitte; 2019.
- [20] Health Education England, NHS. The Topol review: preparing the healthcare workforce to deliver the digital future. Health Education England; 2019.
- [21] Ren W, Huang C, Liu Y, Ren J. The application of digital technology in community health education. *Digit Med.* 2015; 1(1): 3-6. doi: 10.4103/2226-8561.166366
- [22] Azzopardi-Muscat N, Ricciardi W, Odone A, Buttigieg S, Zeegers Paget D. Digitalization: potentials and pitfalls from a public health perspective. *Eur J Public Health.* 2019; 29(Suppl 3): 1-2. doi: 10.1093/eurpub/ckz169
- [23] World Health Organization [WHO]. Global strategy on digital health 2020-2025. Geneva: WHO; 2021.
- [24] Carboni C, Wehrens R, van der Veen R, de Bont A. Conceptualizing the digitalization of healthcare work: A metaphor-based Critical Interpretive Synthesis. *Soc Sci Med.* 2022; 292: 114572. doi: 10.1016/j.socscimed.2021.114572

- [25] Gjellebæk C, Svensson A, Bjørkquist C, Fladeby N, Grundén K. Management challenges for future digitalization of healthcare services. *Futures*. 2020; 124: 102636. doi: 10.1016/j.futures.2020.102636
- [26] McKee M, van Schalkwyk MCI, Stuckler D. The second information revolution: digitalization brings opportunities and concerns for public health. *Eur J Public Health*. 2019; 29(Suppl 3): 3-6. doi: 10.1093/eurpub/ckz160
- [27] Surekha BC, Karanati K, Venkatesan K, Sreelekha BC, Kumar VD. E-learning during covid-19 pandemic: a surge in childhood obesity. *Indian J Otolaryngol Head Neck Surg*. 2022; 74(Suppl 2): 3058-64. doi: 10.1007/s12070-021-02750-2
- [28] Naslund JA, Bondre A, Torous J, Aschbrenner KA. Social media and mental health: benefits, risks, and opportunities for research and practice. *J Technol Behav Sci*. 2020; 5(3): 245-57. doi: 10.1007/s41347-020-00134-x

# Effectiveness of Telemedicine in Type 2 Diabetes Mellitus, Bueng Kan Hospital, Bueng Kan Province, Thailand

Krudsada Sirichaisit, Akaphol Kaladee \*, Warangkana Chankong

School of Health Science, Sukhothai Thammathirat Open University, Nonthaburi, Thailand

## Abstract

**Background:** This study aims to study the effectiveness of telemedicine in type 2 diabetes patients. The safety and illness cost evaluation are the secondary objectives.

**Method:** This retrospective study was designed in the interrupted time series. The study was performed in two periods. In the first period, pre-telemedicine was between March and September 2021. The later period, telemedicine was between October 2021 and June 2022. The intervention of this study is telemedicine. This study was performed among type 2 diabetes patients that received telemedicine service in Bueng Kan Hospital, Thailand. The total population is 973 patients who were excluded from chronic kidney disease stage 5. Simple random was performed. The results were analyzed by percentage, mean, standard deviation, median, and interquartile range. The effectiveness of telemedicine in HbA1C decline was analyzed by segmented regression analysis. The safety of telemedicine was evaluated by hypoglycemic and hyperglycemic coma, analyzed by Exact McNemar significance probability. The cost of illness reduction was evaluated by Wilcoxon Signed-Rank test.

**Results:** A total of 217 patients were enrolled in this study. The findings showed that: (1) HbA1C decreased from baseline from 12.89% to 2.63% (95% CI: 0.05 to 5.21) statistical significantly (p-value<0.05); (2) no difference in acute complications after telemedicine; and (3) the cost of illness decreased by 490.28 baht statistical significantly (p-value < 0.001) after telemedicine.

**Conclusion:** This study's results can be concluded that telemedicine in type 2 Diabetes Mellitus patients is efficient, safe, and can reduce the cost of illness.

**Keywords:** Type 2 Diabetes Mellitus, Telemedicine, Effectiveness, Safety, Cost of illness

## 1. Introduction

Based on Sustainable Development Goals (SDGs) that were jointly set in 2000, most countries around the world at the United Nations meeting, including Thailand participated in the adoption of the SDGs agree on the 17 main goals. Goal 3.4 is to reduce premature deaths from non-communicable diseases (NCDs) by one-third through prevention and control. NCDs are a very important problem that causes death in the world [1, 2].

From the 20-year National Strategic Plan of Thailand which has important goals of stability,

prosperity, and sustainability, the development of quality of life and good health for the country's people is very important. The Ministry of Public Health has set the goals of the strategic plan that sustainable health system is part of the management of the health system. The management of chronic NCDs, which is not only a direct but also an indirect cause of death, is an important issue that must be addressed [3, 4].

In the face of the COVID-19 pandemic, medical services must be restructured by changing to a new normal, which requires social distancing to prevent the disease transmission of

\* Corresponding author.

E-mail address: Akaphol.kal@stou.ac.th (Akaphol Kaladee)

COVID-19. Bueng Kan Hospital has begun to conduct telemedicine for diabetic patients based on the benefit of the study on the cost-effectiveness of telemedicine in the treatment of type 2 diabetes in a systematic review and meta-analysis. It was reported that from a systematic review of 47 studies, telemedicine could reduce hemoglobin A1C (HbA1C) and showed more cost-effective than traditional treatment [5]. The other study in Saudi Arabia of telemedicine during the COVID-19 pandemic period presented the same benefits resulting in reduced HbA1C from  $9.98 \pm 1.3$  to  $8.32 \pm 1.3$  statistically significant (95% CI=1.43–1.88;  $P < 0.001$ ) [6]. In primary care setting, telemedicine has same positive benefit in glycemic control [7]. Telemedicine can classify in 4 types of the following [8].

1. Telemonitoring: Use of the electronic device to send clinical data from patients to health professionals.
2. Teleconsultation: Use of information communication technology (ICT) for diagnosis and consultation from health professional to patient.
3. Tele-education: Patient education via the ICT.
4. Telehomecare: Use of ICT for treatment/care to the patient.

To the best of our knowledge, there has been no province study on the effectiveness of telemedicine in the rural area of Thailand. Therefore, telemedicine in Bueng Kan has been continuously developed and investigated to examine the various aspects from telemedicine in effectiveness, safety, and cost.

## 2. Methods

### 2.1. Research design and setting

This retrospective study was designed in the interrupted time series. The study was performed in two different periods. The first period, pre-telemedicine was examined between March 2021 and September 2021. The later period, telemedicine was carried out from October 2021 to June 2022. The intervention was telemedicine.

### 2.2. Population and samples

The total population was studied from 973

patients. Simple random method was performed. The sample size was calculated by comparing the mean of two dependent groups. The previous data from 20 patients were examined by telemedicine with an alpha of 0.05 and a power of 80%. The sample size was calculated to include at least 46 patients. This study included 217 Type 2 Diabetes patients with a previous HbA1C greater than 7.0% (before March 2021) and receive pre-telemedicine treatment in March 2021 and September 2021, telemedicine in October 2021 to June 2022. The exclusion criteria are chronic kidney disease stage 5 patients.

### 2.3. Telemedicine

Telemedicine was performed on MohPrompt platform between Bueng Kan Hospital and 14 subdistrict health promotion hospitals in a one-stop service. The hospital information system of the subdistrict health promotion hospitals was on cloud service then the doctor could view and edit electronic medical records including medication prescriptions (Fig. 1). The telemedicine services provide to patients were treatment, follow-up, and teleconsultation.

### 2.4. Cost of illness

The cost of illness in this study was categorized into direct and indirect costs. The direct cost was divided into medical costs and non-medical costs. The medical cost was determined from both drug and laboratory test costs. The non-medical cost was examined by the meal and travel expenses. The indirect cost was collected from the work absence cost [9].

### 2.5. Statistical Analysis

The generalized characteristics were described using descriptive statistics, including a percentage for categorical variables. Continuous variables were reported as mean and standard deviation of normally distributed variables and median, interquartile range of non-normally distributed variables. Compared to different HbA1C use the segmented regression analysis [10]. Compared to the divided type of cost of illness using the Wilcoxon Signed-Rank test analysis due to the non-normal distribution of data.

## NCD Telemedicine on Cloud

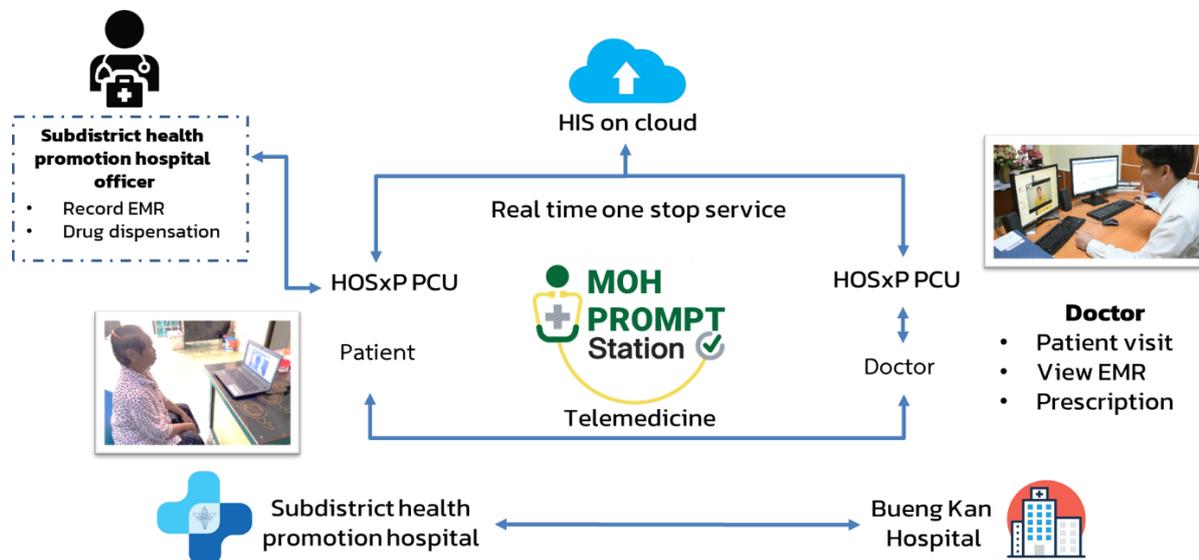


Fig. 1. NCD telemedicine service diagram on cloud.

Table 1. Clinical characteristics of type 2 diabetes patients.

Characteristics	Patients (217 cases)	Percentage
<b>Sex</b>		
Male	15	6.9
Female	202	93.1
<b>Age (years)</b>		
35-39	1	0.5
40-44	6	2.8
45-49	10	4.6
50-54	25	11.5
55-59	51	23.5
60-64	48	22.1
65-69	44	20.3
>70	32	14.7
Mean (S.D.)	61.1 (8.1)	
Median (IQR)	61 (11.5)	
<b>Marital Status</b>		
Married	187	86.1
Divorce	16	7.4
Single	14	6.5
<b>Education</b>		
No education	18	8.3
Elementary school	100	46.1
Primary school	57	26.3
Junior high school	31	14.3
High school	11	5.0

Table 1. Clinical characteristics of type 2 diabetes patients (cont.)

Characteristics	Patients (217 cases)	Percentage
<b>Occupation</b>		
Farmer	135	62.2
Freelance	45	20.7
No occupation	28	12.9
Merchant	7	3.2
Officialdom	1	0.5
Other	1	0.5
<b>Health Insurance</b>		
Universal Coverage (UC)	216	99.5
Civil Servant Medical Benefit Scheme (CSMBS)	1	0.5
<b>Income (Baht)</b>		
Mean (S.D.)	6,016.59 (4,191.98)	
Median (IQR)	5,000 (3,500)	
<b>Comorbidity</b>		
Hypertension	17	8.4
Dyslipidemia	52	25.7
Hypertension with Dyslipidemia	133	65.9
<b>Body Mass Index (BMI) (kg/m<sup>2</sup>) Mean (S.D.)</b>	25.7 (4.9)	

IQR= Interquartile Range, SD=Standard Deviation

## 2.6. Ethical issue

This study was conducted after the internal review board and hospital ethics committee approved at Bueng Kan Hospital (BKHEC2022-10).

## 3. Results

The demographic data of the patients are presented in Table 1. A total of 217 type 2 diabetes patients were treated by telemedicine at Bueng Kan Hospital. Most of the patients were females (93.1%) with the most common age in the range of 55-59 years (23.5%). The majority were married (86.1%) and the most educational level was Elementary school (46.1%). The major occupation was in agriculture (62.2%). Most health insurance is universal coverage (99.5%). The average income is 5,000 Baht (IQR=3,500). The co-morbidities were 65.9 percent of hypertension and hyperlipidemia. The mean BMI was 25.7 ( $\pm 4.9$ ) kg/m<sup>2</sup>.

Changes in the averaged blood glucose (HbA1C) were analyzed, divided into the period before telemedicine use for the period March 2021-September 2021 (7 months) and the period when telemedicine was used. In the period from

October 2021 to June 2022 (9 months), the data characteristics are shown in Fig. 2. Segmented regression analysis was used.

HbA1C prior to telemedicine was 12.89% (95% CI: 10.327 to 15.459), with no significant difference in the trends in HbA1C levels (P-value=0.533). After the telemedicine was applied use, it was found that the HbA1C decreased by -2.63% (95% CI -5.210 to -0.047) statistical significantly (P-value < 0.05). The data analysis was shown in Table 2.

In the diabetic complications assessment by assessing hyperglycemic and hypoglycemic coma among 217 patients with type 2 diabetes, there were 3 cases of hyperglycemic coma before telemedicine. After treatment through telemedicine, 2 cases of hyperglycemic coma were found. Exact McNemar significance probability test statistics were used in the analysis, which was not statistically different. (McNemar's Chi-Square =0.33, p-value 1.000) (Table 3). There are no patients who had hypoglycemic coma before and after telemedicine. In assessing the cost of illness, the study found that the cost of medical care during the time of telemedicine service increased significantly in all categories, including the cost

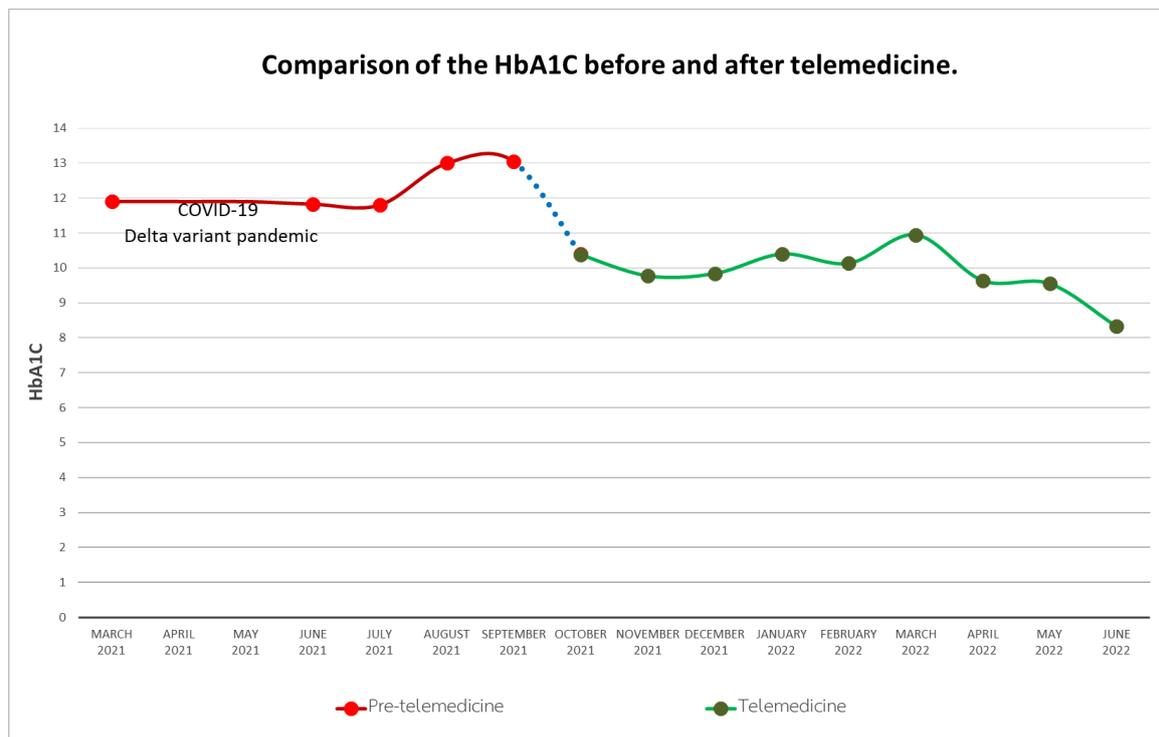


Fig. 2. Comparison of monthly HbA1C before and after telemedicine.

Table 2. Segmented regression analysis of the difference in HbA1C before and after telemedicine periods.

Parameter Estimation	Coefficient	Standard Error	95% CI	t	P-value
Constant (Intercept) ( $\beta_0$ )	12.89	1.31	10.33 to 15.46	9.87	<0.001
Baseline HbA1C trend ( $\beta_1$ )	0.18	0.29	-0.39 to -0.75	0.63	0.533
HbA1C change after telemedicine ( $\beta_2$ )	-2.63	1.31	-5.21 to -0.05	-2.00	0.046*
HbA1C trend change after telemedicine ( $\beta_3$ )	-0.13	0.03	-0.18 to -0.07	-4.48	<0.001

CI = Confidence Interval

\* $p < 0.05$  is statistically significant.

Table 3. Comparison of the acute complications before and after telemedicine.

Pre-telemedicine	Complication	Telemedicine		total	p-value
		Case (percentage)			
		hyperglycemia	normal		
	hyperglycemia	1 (50.0)	2 (0.93)	3 (1.38)	1.000
	normal	1 (50.0)	213 (99.07)	214 (98.62)	
	total	2 (100.0)	215 (100.0)	217 (100.0)	

of medicines and laboratory tests. The cost of medicine increased by 229.96 baht during the 6-month period, the laboratory cost increased by 173.69 baht during the 6-month period, and the total medical cost increased by 403.66 baht

during the 6-month period (Table 4).

It was also observed that non-medical costs during telemedicine services decreased significantly in all categories, such as meal and transportation costs. The average cost of food for

Table 4. Comparison of cost of illness before and after telemedicine.

Cost of illness	Pre-telemedicine		Telemedicine		Z	p-Value
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)		
<b>Medical cost</b>						
Drugs cost	377.60 (327.75)	297 (256.57)	607.56 (407.55)	514.8 (328.05)	-12.24	<0.001
Laboratory testing cost	17.55 (32.81)	11.01 (3.67)	191.24 (43.17)	201.75 (53.90)	-12.74	<0.001
Total medical cost	395.14 (336.04)	313.41 (247.11)	798.80 (414.07)	706.79 (335.86)	-12.70	<0.001
<b>Non-medical cost</b>						
Meal cost of patient	115.92 (72.1)	100 (80)	48.59 (92.83)	50 (100)	-9.73	<0.001
Meal cost of relative	133.69 (81.55)	100 (100)	41.06 (74.12)	0 (65)	-10.68	<0.001
Travel expense of patient	207.33 (126.72)	200 (200)	47.56 (74.76)	0 (100)	-11.11	<0.001
Travel expense of relative	212.21 (135.44)	200 (200)	28.25 (45.23)	0 (50)	-11.80	<0.001
Total non-medical cost	669.15 (296.75)	620 (300)	165.46 (169.82)	150 (195)	-12.32	<0.001
<b>Indirect cost</b>						
Work absence cost of patient	250 (177.23)	300 (350)	64.98 (119.49)	0 (25)	-10.28	<0.001
Work absence cost of relative	275.51 (205.83)	300 (275)	67.28 (129.87)	0 (0)	-10.58	<0.001
Total indirect cost	522.51 (285.09)	600 (400)	132.26 (200.58)	0 (300)	-11.73	<0.001
<b>The total cost of illness</b>	1586.80 (564.14)	1532.74 (646.62)	1096.52 (510.51)	1009.74 (574.38)	-11.10	<0.001

\*p < 0.05 is statistically significant.

patients and relatives was reduced by 67.33 baht, and 92.63 baht, respectively. The average travel expensed for patients was reduced to 159.77 baht, while the average relative travel expensed was reduced by 183.96 baht. Total non-medical costs could be reduced to 503.69 baht (Table 4).

Results of the study on indirect costs revealed that the work absence cost in telemedicine could be reduced in both patients and their relatives statistical significantly. The average loss of patient income was 185.02 baht, the average relative income loss was 208.23 baht, and the total indirect costs were 390.25 baht (Table 4).

The average cost of illness before and after using telemedicine was 1,586.80 baht, and 1,096.52 baht, respectively. The average decrease in the illness cost was 490.28 baht.

#### 4. Discussion

The effectiveness of telemedicine was measured by HbA1C. Telemedicine has a lower HbA1C level than the previous service. This is consistent with the study in Japan during the COVID-19 outbreak. The study showed that telemedicine had a statistically significant reduction in mean HbA1C levels in the presence of base HbA1C above 7% [11]. The study conducted the telemedicine system on people with type 2 diabetes during the COVID-19 pandemic and followed for four months. Glycemic control was measured using HbA1C before and after telemedicine. It was found that HbA1C before was  $9.98 \pm 1.3$  and after using telemedicine was  $8.32 \pm 1.3$ , which was able to reduce statistically significant  $1.66 \pm 1.29$ .

(CI=1.43–1.88; P-value<0.001) [6]. Although the HbA1C level of the telemedicine group is lower than the pre-telemedicine, the HbA1C level does not achieve the standard target (HbA1C< 7.0%). Nevertheless, the trend of HbA1C is continuously declining. If the service is continuously used the HbA1C level may achieve the goal.

There is no difference in the safety of acute diabetic complications. There are few patients that occur with hypoglycemic coma in each group, and these are not statistically significant. No hyperglycemic coma in both groups is observed. These results are corresponding with the systematic review, the effect of telemedicine was not different in the occurrence of hypoglycemia that had a relative risk=0.59 (95%CI = 0.17-2.05) [12].

In the cost of illness aspect of telemedicine, the total illness cost is lower in the telemedicine group compared to the previous service group. This result is due to the non-medical direct cost and the indirect cost. The medication and laboratory tests were increased after telemedicine implementation due to high-frequency follow-up and adjusting medication when the A1C was not targeted. This present study confirms the study in Saudi Arabia. This is a retrospective study of patients with type 2 diabetes whose blood sugar levels were uncontrolled. In the study, the HbA1C value greater than 9 was defined as a comparative study, compared to a control group of 100 patients. The average cost was \$1,285.27, compared to \$1,106.85. Compared to treatment outcomes, HbA1C reduction was 1.82% in telemedicine, and 1.52% in prior service. The Incremental cost-effectiveness ratio (ICER) was \$632.67 per 1% HbA1C reduction [13].

## 5. Conclusion

The effectiveness of telemedicine in type 2 diabetic patients was greater than the previous service. The safety is not different in the two groups. The total illness cost was lesser in telemedicine because of the non-medical cost and indirect cost. Due to the unreached HbA1C goal, the results of telemedicine treatment should be studied for a longer period until the HbA1C level can reach the controllable threshold.

Telemedicine is suitable for the new normal medical service in type 2 diabetes patients. Due to a large number of people with type 2 diabetes, therefore, the responsibility of caring for patients should be divided into each primary care unit (PCU) or a network primary care unit (NPCU). It should improve the coverage and efficiency of telemedicine services. The extended coverage of this service can improve diabetic control and finally will reduce diabetic complications. Finally, telemedicine will improve the ultimate goal of Thailand and SDGs.

## Conflict of interest

There is no conflict of interest.

## References

- [1] Aroonsrimorakot S, Vajjaradul Y. UN sustainable development goals: 17 aspects for future world. *Interdisciplinary Research Review*. 2016; 11(3): 1-7. doi: 10.14456/jtir.2016.3
- [2] NCD Countdown 2030 Collaborators. NCD Countdown 2030: pathways to achieving Sustainable Development Goal target 3.4. *Lancet*. 2020; 396(10255): 918-34. doi: 10.1016/S0140-6736(20)31761-X
- [3] Pokpermddee P. Twenty-year national strategic plan for public health (B.E. 2561-2580). *Journal of Health Science*. 2020; 29(1): 173-86.
- [4] Chaiphak S, Phengchan W, Rotchanaphitthayakon W, Tangkiratchai J. Strategic preparation for health promotion, disease prevention and consumer protection, 2017-2036. *Thailand Journal of Health Promotion and Environmental Health*. 2019; 4(3): 11-8.
- [5] Zhai YK, Zhu WJ, Cai YL, Sun DX, Zhao J. Clinical- and cost-effectiveness of telemedicine in type 2 diabetes mellitus: a systematic review and meta-analysis. *Medicine (Baltimore)*. 2014; 93(28): e312. doi: 10.1097/MD.0000000000000312
- [6] Tourkmani AM, ALHarbi TJ, Rashed AMB, Alrasheedy AA, ALMadani W, ALJuraisi F, et al. The impact of telemedicine on patients with uncontrolled type 2 diabetes mellitus during the COVID-19 pandemic in Saudi Arabia: Findings and implications. *J Telemed Telecare*. 2021: 1357633X20985763. doi: 10.1177/1357633X20985763 (in press)
- [7] Zhang A, Wang J, Wan X, Zhang Z, Zhao S, Guo Z, et al. A meta-analysis of the effectiveness

- of telemedicine in glycemic management among patients with type 2 diabetes in primary care. *Int J Environ Res Public Health*. 2022; 19(7): 4173. doi: 10.3390/ijerph19074173
- [8] Wiriyapong P, Pongsura S, Fuanchan A, Dhippayom T. The use of telemedicine to support type 2 diabetes care. *J Med Health Sci*. 2021; 28(2): 165-77.
- [9] Riephaibun A. Cost of illness analysis. [cited 2022 Jun 15]. Available from: <http://irem.ddc.moph.go.th/uploads/tiny/research/course/HTA/Cost%20Evaluation%20Workshop/2%20Cost-CoI-22Nov16.pdf>
- [10] Kaladee A. Segmented regression analysis of interrupted time series design: application in health science research. *Journal of Safety and Health*. 2017; 10(37): 1-9.
- [11] Onishi Y, Yoshida Y, Takao T, Tahara T, Kikuchi T, Kobori T, et al. Diabetes management by either telemedicine or clinic visit improved glycemic control during the coronavirus disease 2019 pandemic state of emergency in Japan. *J Diabetes Investig*. 2022; 13(2): 386-90. doi: 10.1111/jdi.13546
- [12] Faruque LI, Wiebe N, Ehteshami-Afshar A, Liu Y, Dianati-Maleki N, Hemmelgarn BR, et al. Effect of telemedicine on glycosylated hemoglobin in diabetes: a systematic review and meta-analysis of randomized trials. *Cmaj*. 2017; 189(9): E341-64. doi: 10.1503/cmaj.150885
- [13] Faleh AlMutairi M, Tourkmani AM, Alrasheedy AA, TJ AL, Bin Rsheed AM, M AL, et al. Cost-effectiveness of telemedicine care for patients with uncontrolled type 2 diabetes mellitus during the COVID-19 pandemic in Saudi Arabia. *Ther Adv Chronic Dis*. 2021; 12: 20406223211042542. doi: 10.1177/20406223211042542

# Effect of Adaptive Seating in Postural Control among Children with Cerebral Palsy: A Systematic Review

Bishnu Dutta Acharya <sup>a, b</sup>, Saipin Prasertsukdee <sup>a, \*</sup>, Rawewan Lekskulchai <sup>a</sup>, Prem Laxmi Baniya <sup>c</sup>

<sup>a</sup> Faculty of Physical Therapy, Mahidol University, Salaya, Phuttamonthon, Nakhon Pathom, Thailand

<sup>b</sup> Karnali Academy of Health Sciences, Jumla Nepal

<sup>c</sup> Nepal Health Research council, Ramsha Path Kathmandu, Nepal

## Abstract

**Background:** Children with cerebral palsy (CP) with Gross Motor Functional Classification System (GMFCS) level III to V have weak anti-gravity muscles. So, they required the adaptive seating system (AdSS) for postural control. Many studies reported positive results of AdSS on postural control. However, the quality of studies is crucial to ensure the benefits of AdSS. Therefore, the effectiveness of AdSS on postural control should be reviewed with strong evidence. Objective of this study was to systematically review the effect of AdSS for postural control in CP children with GMFCS III to V.

**Method:** This systematic review followed the Preferred Reporting Guideline for Systematic Review and Meta-analysis (PRISMA) guideline. PubMed, Web of Science, Embase, CINAHL, and Cochrane databases from the years 1991 to March 2022 were used to search. 293 articles were found, among which 14 articles met the inclusion criteria. Keywords used in the search were CP, children, postural control, or postural balance. Inclusion criteria were cerebral palsy participants with GMFCS III to V; aged <18 years; adaptive seating intervention; postural control outcome and papers in English. Exclusion criteria include ambulatory CP, case series, and case reports. Articles were independently reviewed, and quality assessment was done by 2 reviewers and verified by experts.

**Results:** 14 articles were included, 3 were good quality, 8 were fair and 3 poor. There were 5 cohorts, 4 experimental, and 5 cross-sectional studies, and no RCT was found. Participants were GMFCS Level III to V with 51.9% male. These studies reported the benefits of AdSS on body function activities, participation, and environmental aspects.

**Conclusion:** This systematic review shows that postural control enhances the sitting ability, and hands performance, and promotes the functional level of children with cerebral palsy. Fair to good quality studies demonstrated adaptive seating systems are effective on postural control however there was a need for prospective RCTs. Although this study has strong clinical significance but couldn't perform activity performance, sitting posture, and sub-group to make the study more heterogeneous. Fair to good quality studies demonstrated AdSS are effective on postural control however prospective RCTs are needed.

**Keywords:** Adaptive seating, Postural control, Cerebral palsy, Children

## 1. Introduction

In the global scenario, cerebral palsy is the most common physical disability among children with an estimated prevalence in developing

countries is 3.4/1000 and 1 in 700 in developed countries [1, 2]. Cerebral palsy is defined as a group of permanent disorders of the developmental movement and posture, caused by non-progressive

\* Corresponding author.

E-mail address: saipin.pra@mahidol.edu (Saipin Prasertsukdee)

disturbances in infants brain leading to activity limitation [3]. The motor impairments is classified based on gross motor function classification system (GMFCS) level I to V [3, 4]. Children with CP with GMFCS level III to V have a postural control deficit and are suggestive for adaptive seating systems. Postural control is defined as alignment or adjustment of body segments against gravity without failing [5]. “Adaptive seating is any modification to seating devices for the functional improvement and postural control among mobility-impaired individuals” [6]. Several studies have recommended the use of adaptive seating systems (AdSSs) for postural correction [6-9]. Up to 40% of children with CP who are non-ambulant may require the prolonged use of an AdSSs [10]. Sitting is one of the fundamental activities of every individual. Around 65% of children CP develop scoliosis and 28% have hip displacement surgery [11].

The goal of AdSSs in non-ambulant children with CP is to promote upper limb abilities, performance in daily activities, participation, ability to interact with family and relatives, and prevent complications [8, 12]. AdSSs is the most common intervention aimed to support postural control, to enable children sit independently to minimize caregiver burden, stress, depression, and anxiety [7, 13].

A systematic review performed on the effectiveness of adaptive seating on sitting posture and postural control in children with CP with GMFCS IV and V found limited evidence for supporting the effect of postural control on functional abilities [6]. This review included fourteen low quality studies published between 1980 to July 2007. This study lacks pragmatic evidence for resulting in adaptive seating devices to improve postural control, in children with CP. So, author further suggested on the effectiveness of AdSSs on postural control and this gap will be addressed by these study.

The latest systematic review on AdSSs is of 2015 on adaptive seating systems among children of GMFCS levels IV and V using the International Classification System of Functioning, Disability and Health for children and youth version (ICF-CY) domains [14]. The study reviewed the effect

of AdSSs on children age  $\leq 18$  years with CP focusing on child related outcome measurements and disability domains of the ICF-CY. They included 9 studies with low-level evidence level IV according to Sackett [15] and recommended for higher levels of evidence-based studies on adaptive seating prioritizing upper extremity function using a postural support system.

There were limited high-level studies to support the impact of AdSSs on postural control. The knowledge gap of this will be addressed by this systematic review. The research question for this review is “Does adaptive seating in postural control influence the cerebral palsy child seating?”

## 2. Methods

This systematic review followed the Preferred Reporting Guideline for Systematic Review and Meta-analysis (PRISMA) guideline. The inclusion criteria's includes: cerebral palsy participants with GMFCS level III to V; aged  $< 18$  years; adaptive seating intervention; outcomes was postural control; and papers published in English. Whereas exclusion criteria's includes ambulatory CP; and case series and case reports. The researchers review the papers on the adaptive seating from 1983 to September 2021. The data were searched from five different database by two reviewers with the help of expert librarian. The medical subject heading (MESH) terms were entered into systematic review (SR)-Accelerator polyglot search. The review authors undertook a comprehensive search in PubMed national library of medicine (NIH) (January 1983 – September 2021), CINAHL (January 1983 – September 2021), Web of science (January 1983 – September 2021), Cochrane (January 1983 – September 2021), and Embase (January 1983 – September 2021). Hand searching was also performed on the reference lists of previous reviews and articles. The search strategy comprised the following MESH headings or key words:

- AND (child\* [tiab] OR “Child”[Mesh] OR baby [tiab] OR babies [tiab] OR infant\* [tiab] OR “Infant”[Mesh] OR neonat\* [tiab] OR neo-nat\* [tiab] OR newborn\* [tiab] OR new-born\* [tiab] OR

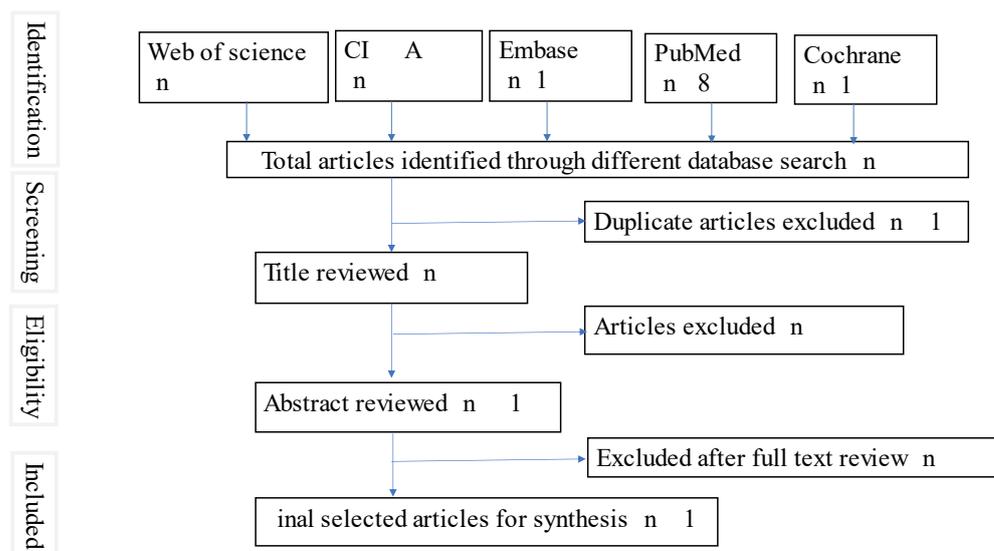


Fig. 1. Flow chart for study selection based on established inclusion and exclusion criteria.

toddler\*[tiab] OR paediatric\*[tiab] OR pediatric\*[tiab])

- AND (cerebral palsy [tiab] OR “Cerebral Palsy”[Mesh] OR Spasticity\*[tiab] OR athetoid\*[tiab] OR hemiplegia [tiab] OR diplegia [tiab] OR Quadriplegia [tiab])
- Postural control [tiab] OR Postural Balance”[Mesh]

The data were extracted from 14 papers and was done based on research questions. To minimize the bias and decrease the error, two reviewers review the articles and were further confirmed by experts.

### 2.1. Data synthesis

After duplicate studies were removed, the study titles, abstracts and full text were independently reviewed, and consensus reached between the reviewers. The details of the data were extracted from the 14 selected papers which were verified by expert reviewers. The details are shown in PRISMA flow chart Fig. 1. Study characteristics included demographic details, study design, GMFCS Level, age distribution, and treatment or control groups which are reported in Table 1. The different studies used various methods of intervention for adaptive seating for the postural correction sitting

intervention, and activity performance, and clinical implication.

### 2.2. Quality assessment

The quality of studies and risk of Bias was assessed using the Downs and Black quality assessment tool [16] by BDA and SP. There were mostly good to fair 8/14 and poor 3/14. The checklist consists of 27 items assessing the quality of studies with RCT and Non-RCT in the health care interventions. [Points are scored from 0 to 1 (1-Yes, 0- No) except for the item five which have score from 2 to 0 (2-Yes, 1- Partially, 0- No). The last 27 related to sample power consist of score from 0-1 (yes-1, No-0, and unable to determine- 0)]. The maximum score was 28. Higher the score better the quality assessment. The score from 26-28 is considered as excellent; 20-25 is good; 15-19 is fair; and less than <14 is poor. In this systematic review the included articles are Sackett level II (Cohort) and level III (cross-sectional) study designs with scores from 24 which is good (20-25) to poor (<14) [15].

## 3. Results

The search identified 293 studies based on titles and abstracts. After removal of duplicates, 19 articles were excluded, and the remaining were

further screened as shown in figure. The final 14 articles meet the inclusion criteria for full text (Fig.1) [8, 17-29]. The quality of the paper was assessed using Downs and Black quality assessment checklist. Quality assessment showed three studies were good with score from (20-24), eight fair (15-19) and the remaining three were of poor (<14) quality. 21.42% (3/14) of total included articles were of good to fair quality.

There were 5 cohorts, 4 experimental, and 5 cross-sectional study. No randomized controlled trials were identified on this topic.

The study population characteristics are summarized in Table 1. In total there were 208 children with CP aged from eighteen months to 18 years who used adaptive seating for postural control. Regarding the gender identification, 1 studies did not give details of gender [19] and the remaining included a total of 108 (51.9%) male and 100 (48.1%) female participants. Studies included GMFCS Level III to V participants, and few studies had the participants from I to V although majority of them were from III to V.

### 3.1. The effect of adaptive seating in postural control

Three of 14 studies on postural control (PC) were chosen for inclusion were of low quality [27-29]. The various adaptive seating were used, including planter flat seat, sacral pad and knee blocks in adaptive seating [22]; commercial modular contoured seating systems [8]; custom made orthosis [19]; adapted hammock without seat back support [26]; saddle seat [24]; paper based seating and standing chair [17]; wheelchair with joystick [21]; X-PANDA seating [27]; adaptive chair with positioning [20]; tilting seat surface [25]; custom made wheelchair [28]; and Maxit, modulated chair [23]. For the postural control there were 14 studies with grade score of  $\frac{3}{4}$  (Moderate) and the quality scoring was from good (n=3), fair (n=8) and (poor n=3).

Inthachom and colleagues [8] showed a short-term beneficial effect on children's seated posture that enhanced body function, activities, engagement, and environmental elements. In 58 children with CP, Hadders-Alegra and colleagues

[25] examined the impact of seat surface on postural control during reaching (unilateral and bilateral CP). The study found that children with bilateral CP who usually had GMFCS III-V were able to maintain best postural control in horizontal condition of the seat surface. The study on saddle seating showed improvement in postural control in children with CP measured by the Sitting Assessment for Children with Neuromotor Dysfunction (SACND) [24]. Myhr and Wendt studied were for the functional sitting position in children with CP. Functional sitting position consisted of the seat slope forwarded; the pelvis was supported by back rest; and 45° angle of hip belt. They found the improvement of postural control measured by Sitting Assessment Scale (SAS). Sahinoglu and colleagues [19] compared the commercially available chair with black support custom-made body and pelvic positioning orthosis for postural alignment and extremity function where they found a significant difference in postural control measured by the Seated Postural Control Measures (SPCM) and SAS.

## 4. Discussion

The objective of this systematic review was to find the effect of adaptive seating on postural control among GMFCS level III to V. Children with cerebral palsy lack postural control, however proper use of AdSS aids with posture correction, activation of extensor muscles and anti-gravity muscles, and increased trunk stability [19]. AdSS are preferred by parents, physiotherapists, occupational therapists, and clinicians for improving children's activity performance, participation, and use of upper limb in functional activities by controlling postural habits [8, 17, 30].

Study by Hadders-Alegra [25], Machado [26] and Inthachom [8] have fulfilled most of the criteria of Down's and Black quality assessment [16]. Studies have found that participants who received the interventions in adaptive seating showed a significant improvement in postural abnormal curvature, sitting postures and hand performance, improvement in daily activities. These papers have concluded for immediate, short term and long-term benefit for GMFCS level III to V CP children [8, 17, 25, 30].

Table 1. Population characteristics.

Studies	Design	GMFCS Level	Age (Years)	Male: Female	Treated (n)	Control (n)	Adaptive seating systems	Recommendation
Myhr et al. [23]	Observational	III-IV	2-16	18:8	23	NP	Maxit real chair, Rida ITM, and relax comfort Akema chair.	Use of neck support reinforce the reflex in sitting position.
Pope et al. [29]	Cohort	IV-V	2-9	NS	9	NP	Seating and mobility system	Postural management should not be focused on sitting only.
Reid [24]	Cross-sectional	I - IV	4-9	5:1	6	NP	Flat bench and saddle seat	Future work on saddle should emphasis environmental effects too.
McDonald et al. [22]	Cohort	V	7-14	12:11	23	NP	sacral pads and knee blocks in adaptive seating	Focused on reliable outcome measures.
Algra et al. [25]	Cross-sectional	I - V	2 - 11	28:26	58	NP	Tilting in seat surface	Findings were more focused on surface inclination than level of disability.
Cimolin et al. [27]	Experimental	V	6-10	5:5	10	NP	X-PANDA seating system	Lacks kinematic information
Lacoste et al. [28]	Experimental	III-V	8 - 18	17:14	31	NP	Costume made wheelchair seating system	Need to prioritize on objective outcome measures.
Ju et al. [18]	Cross-sectional	II - IV	6-12	7:9	12	16	4 leg height adjustable stool without back and arm support	Valid outcome measures to determine the clinical application.
Liu et al. [21]	Cross-sectional	II - V	6-12	14:6	20	14	Bimanual interface and unilateral joystick pediatric power wheelchair	Need to include all category of CP

Table 1. Population characteristic (cont.)

Studies	Design	GMFCS Level	Age (Years)	Male: Female	Treated (n)	Control (n)	Adaptive seating systems	Recommendation
Sahinoğlu et al. [19]	Cross-sectional	III - V	3-6	NA	20	NP	standard chair, adjustable seating system and custom-made orthosis.	Reliable measurement tools are required.
Seyhan [20]	Cohort	III- IV	1.6 -16	20:21	41	NP	Adaptive chair and hip positioning seat	Subjectivity of outcome measure.
Machado et al. [26]	Quasi experimental	II & III	8-14	2:4	6	6	Adapted hammock, bench and hammock without support	Limited sample size and category of CP.
Barton et al. [17]	Cohort	IV & V	1-6	6:4	10	NP	APT seating or standing frames	More prone to biased.
Inthachom et al. [8]	Cohort	IV & V	2-11	9:11	20	NP	Commercial modular contoured seating system and planar flat seat/flat back seating system	Varied in adaptive seating devices.

The specific of each study are provided in order of quality of assessment score and level of evidence (Downs and Black). Study levels: I = RCT; II = cohort; III = case control; IV = case series. NP= No participants; NS= Not significant; AdSSs= Adaptive seating systems.

From the grade scoring the quality of evidence is moderate (3/4). The true effect is likely to be close to the estimate but there is chance of considerably different. This implies that future trial studies will have good impact on our confidence estimate. In the recent study there were only experimental, cohort and cross-sectional studies.

Cerebral palsy is usually delay diagnosed and there is no any specific inclusion criteria for age group as this study have the participants from age 18 months to 18 years [31]. Our findings shows male participants are more affected than female because CP and developmental disorders are commonly seen among the male children than the female although the reason is unclear [32].

Adaptive seating are primarily used by GMFCS level III to V as this children have postural muscles weakness and can't work against gravity [6]. These children are vulnerable for postural deformity, contractures, respiratory complications, and financial burden for family [33].

Various studies show that AdSS has long term and short-term effect on the postural control. Inthachom and colleagues demonstrate that adaptive setting on wheelchairs among non-ambulatory CP have significant changes on ICF components [8]. Similarly, Barton et al. findings reflect postural support devices enhance motor skills and functions along with minimization of parents' stress [17]. However, Machado findings suggest that Hammock sitting can be option to promote postural control for the short duration [26]. The hip positioning belt improve the upper extremity while performing daily activities [20].

A systematic review by Chung et al found that AdSS are successful at preserving spine curvature, minimizing pelvic posterior rotation and reducing hamstring muscles tension [6]. However, there was no strong conclusion to support this evidence due to limited for supporting evidence for postural control. Angsupaisal in 2015 on severe CP children (GMFCS level IV and V) on child related outcomes following ICF-CY components found limited evidence to generate robust conclusion to support effect of adaptive seating devices [14]. Therefore, in contrast to

those studies, our review found conclusive findings and showed the effectiveness of adaptive seating on postural control. However, rigorous methodological studies such as RCT's were not included in this study due to its unavailability.

Although this study has strong clinical significance but couldn't perform the sub-group to make study more heterogenous for meta-analysis and it was confirmed to English papers.

## 5. Conclusion

Postural control enhances the sitting ability of CP children and promotes the functional level. Fair to good quality studies demonstrated adaptive seating systems are effective on postural control however there was a need for prospective RCTs.

## Recommendations

These systematic reviews suggest that adaptive seating have significant role in the postural control for the children with cerebral palsy with gross motor functional level III to V. To prove the high-level evidence of AdSS clinical trials are suggested as till date there are no studies.

## Acknowledgments

We would like to heartily thank Asst. Prof. Dr. Pagamas Piriyaprasarth and Mr Khanakorn Korkijthamkul for their continuous support during the study period. Our sincere thanks to the faculty of Physical Therapy Mahidol University and my friends for helping to complete this study.

## References

- [1] Lang TC, Fuentes-Afflick E, Gilbert WM, Newman TB, Xing G, Wu YW. Cerebral palsy among Asian ethnic subgroups. *Pediatrics*. 2012; 129(4): e992-8. doi: 10.1542/peds.2011-2283
- [2] McAdams RM, Juul SE. Cerebral palsy: prevalence, predictability, and parental counseling. *NeoReviews*. 2011; 12(10): e564-74. doi: 10.1542/neo.12-10-e564
- [3] Rosenbaum P, Paneth N, Leviton A, Goldstein M, Bax M, Damiano D, et al. A report: the definition and classification of cerebral palsy April 2006. *Dev Med Child Neurol Suppl*. 2007; 109: 8-14

- [4] Brogren E, Hadders-Algra M, Forssberg H. Postural control in sitting children with cerebral palsy. *Neurosci Biobehav Rev.* 1998; 22(4): 591-6. doi: 10.1016/s0149-7634(97)00049-3
- [5] Massion J. Postural control system. *Curr Opin Neurobiol.* 1994; 4(6): 877-87. doi: 10.1016/0959-4388(94)90137-6
- [6] Chung J, Evans J, Lee C, Lee J, Rabbani Y, Roxborough L, et al. Effectiveness of adaptive seating on sitting posture and postural control in children with cerebral palsy. *Pediatr Phys Ther.* 2008; 20(4): 303-17. doi: 10.1097/PEP.0b013e31818b7bdd
- [7] Harris SR, Roxborough L. Efficacy and effectiveness of physical therapy in enhancing postural control in children with cerebral palsy. *Neural Plast.* 2005; 12(2-3): 229-43; discussion 63-72. doi: 10.1155/NP.2005.229
- [8] Inthachom R, Prasertsukdee S, Ryan SE, Kaewkungwal J, Limpaninlachat S. Evaluation of the multidimensional effects of adaptive seating interventions for young children with non-ambulatory cerebral palsy. *Disabil Rehabil Assist Technol.* 2021; 16(7): 780-8. doi: 10.1080/17483107.2020.1731613
- [9] Ryan SE. An overview of systematic reviews of adaptive seating interventions for children with cerebral palsy: where do we go from here? *Disabil Rehabil Assist Technol.* 2012; 7(2): 104-11. doi: 10.3109/17483107.2011.595044
- [10] Himmelmann K, Beckung E, Hagberg G, Uvebrant P. Bilateral spastic cerebral palsy--prevalence through four decades, motor function and growth. *Eur J Paediatr Neurol.* 2007; 11(4): 215-22. doi: 10.1016/j.ejpn.2006.12.010
- [11] Stuberger WA. Considerations related to weight-bearing programs in children with developmental disabilities. *Phys Ther.* 1992; 72(1): 35-40. doi: 10.1093/ptj/72.1.35
- [12] McDonald R, Surtees R, Wirz S. The International Classification of Functioning, Disability and Health provides a Model for Adaptive Seating Interventions for Children with Cerebral Palsy. *British Journal of Occupational Therapy.* 2016; 67(7): 293-302. doi: 10.1177/030802260406700703
- [13] Cheshire A, Barlow JH, Powell LA. The psychosocial well-being of parents of children with cerebral palsy: a comparison study. *Disabil Rehabil.* 2010; 32(20): 1673-7. doi: 10.3109/09638281003649920
- [14] Angsupaisal M, Maathuis CG, Hadders-Algra M. Adaptive seating systems in children with severe cerebral palsy across International Classification of Functioning, Disability and Health for Children and Youth version domains: a systematic review. *Dev Med Child Neurol.* 2015; 57(10): 919-30. doi: 10.1111/dmcn.12762
- [15] Sackett DL. Rules of evidence and clinical recommendations on the use of antithrombotic agents. *Chest.* 1989; 95(2 Suppl): 2s-4s.
- [16] Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *J Epidemiol Community Health.* 1998; 52(6): 377-84. doi: 10.1136/jech.52.6.377
- [17] Barton C, Buckley J, Samia P, Williams F, Taylor SR, Lindoewood R. The efficacy of appropriate paper-based technology for Kenyan children with cerebral palsy. *Disabil Rehabil Assist Technol.* 2022; 17(8): 927-37. doi: 10.1080/17483107.2020.1830442
- [18] Ju YH, Hwang IS, Cherng RJ. Postural adjustment of children with spastic diplegic cerebral palsy during seated hand reaching in different directions. *Arch Phys Med Rehabil.* 2012; 93(3): 471-9. doi: 10.1016/j.apmr.2011.10.004
- [19] Sahinoglu D, Coskun G, Bek N. Effects of different seating equipment on postural control and upper extremity function in children with cerebral palsy. *Prosthet Orthot Int.* 2017; 41(1): 85-94. doi: 10.1177/0309364616637490
- [20] Seyhan K, Kerem-Gunel M. Does stable sitting influence upper limb function in children with cerebral palsy? *Turk J Pediatr.* 2019; 61(1): 79-84. doi: 10.24953/turkjped.2019.01.012
- [21] Liu WY, Chen FJ, Lin YH, Kuo CH, Lien HY, Yu YJ. Postural alignment in children with bilateral spastic cerebral palsy using a bimanual interface for powered wheelchair control. *J Rehabil Med.* 2014; 46(1): 39-44. doi: 10.2340/16501977-1233
- [22] McDonald RL, Surtees R. Longitudinal study evaluating a seating system using a sacral pad and kneeblock for children with cerebral palsy. *Disabil Rehabil.* 2007; 29(13): 1041-7. doi: 10.1080/09638280600943087
- [23] Myhr U, von Wendt L. Improvement of functional sitting position for children with cerebral palsy. *Dev Med Child Neurol.* 1991;

- 33(3): 246-56. doi: 10.1111/j.1469-8749.1991.tb05114.x
- [24] Reid DT. The effects of the saddle seat on seated postural control and upper-extremity movement in children with cerebral palsy. *Dev Med Child Neurol.* 1996; 38(9): 805-15. doi: 10.1111/j.1469-8749.1996.tb15115.x
- [25] Hadders-Algra M, van der Heide JC, Fock JM, Stremmelaar E, van Eykern LA, Otten B. Effect of seat surface inclination on postural control during reaching in preterm children with cerebral palsy. *Phys Ther.* 2007; 87(7): 861-71. doi: 10.2522/ptj.20060330
- [26] Pantoja Machado F, dos Santos Cardoso de Sá C, de Paula Carvalho R. Influência dos diferentes assentos no alinhamento postural: rede adaptada para paralisia cerebral. *Fisioterapia e Pesquisa.* 2020; 27(2): 161-7. doi: 10.1590/1809-2950/19013227022020
- [27] Cimolin V, Piccinini L, Avellis M, Cazzaniga A, Turconi AC, Crivellini M, et al. 3D-Quantitative evaluation of a rigid seating system and dynamic seating system using 3D movement analysis in individuals with dystonic tetraparesis. *Disabil Rehabil Assist Technol.* 2009; 4(6): 422-8. doi: 10.3109/17483100903254553
- [28] Lacoste M, Therrien M, Prince F. Stability of children with cerebral palsy in their wheelchair seating: perceptions of parents and therapists. *Disabil Rehabil Assist Technol.* 2009; 4(3): 143-50. doi: 10.1080/17483100802362036
- [29] Pope PM, Bowes CE, Booth E. Postural control in sitting the SAM system: evaluation of use over three years. *Dev Med Child Neurol.* 1994; 36(3): 241-52. doi: 10.1111/j.1469-8749.1994.tb11837.x
- [30] Washington K, Deitz JC, White OR, Schwartz IS. The effects of a contoured foam seat on postural alignment and upper-extremity function in infants with neuromotor impairments. *Phys Ther.* 2002; 82(11): 1064-76.
- [31] Smithers-Sheedy H, Badawi N, Blair E, Cans C, Himmelmann K, Krageloh-Mann I, et al. What constitutes cerebral palsy in the twenty-first century? *Dev Med Child Neurol.* 2014; 56(4): 323-8. doi: 10.1111/dmcn.12262
- [32] Johnston MV, Hagberg H. Sex and the pathogenesis of cerebral palsy. *Dev Med Child Neurol.* 2007; 49(1): 74-8. doi: 10.1017/s0012162207000199.x
- [33] Farley R, Clark J, Davidson C, Evans G, Maclennan K, Michael S, et al. What is the evidence for the effectiveness of postural management? *Br J Ther Rehabil.* 2003; 10(10): 449-55. doi: 10.12968/bjtr.2003.10.10.13476

# The Clean and Healthy Behavior of Motorcycle Online Drivers in Samarinda, Indonesia

Nur Rohmah <sup>a,\*</sup>, Dina Lusiana Setyowati <sup>b</sup>, Rina Tri Agustini <sup>a</sup>

<sup>a</sup> Department Health Promotion, Faculty of Public Health Mulawarman University, Indonesia

<sup>b</sup> Department Occupation and Health, Faculty of Public Health, Mulawarman University, Indonesia

## Abstract

**Background:** Alcohol consumption, and the use of certain drugs are two behaviors and lifestyle factors that contribute to motorcycle accidents. Since online drivers transport passengers, they must perform well at work. Maintaining a clean and healthy lifestyle while working is one of the considerations that must be made. Living a clean lifestyle is essential for a person's comfort and safety, as well as the safety of their passengers. The research aimed to investigate how online drivers' behaviors of living a clean and healthy lifestyle related to vehicle accidents.

**Methods:** In quantitative research with a cross-sectional methodology, a sample size of 350 respondents. Representatives of the regional coordinators provided the respondent data. Additionally, information is gathered at five locations based on each responder's location. Using Google Forms to complete research questionnaires with five enumerators to prevent research bias. Cramer's V test, Chi-Square test, and Fisher test with 95% CI were used to examine the data.

**Results:** This study found that 54.3% of respondents continued to smoke. Only half of those surveyed (93.1%) engaged in daily activity lasting longer than 30 minutes, while the majority (87.1%) slept for more than seven hours every night. In all, 2.6% of respondents reported only consuming alcohol once a week. 36% of those surveyed admitted to attending the safety briefing prior to work. The results showed a The use of PPE at work and occupational accidents among online motorbike drivers were significantly correlated (p-value 0.008).

**Conclusion:** This research makes recommendations, such as mandating safety briefings at workplaces before the start of workdays and informing online drivers about the use of PPE at the workplace.

**Keywords:** Behavior, Healthy Life, Online drivers

## 1. Introduction

According to the WHO's 2018 Global Status Report on Road Safety (GSRS), 1.35 million people lose their lives in traffic accidents every year, with one life lost every 24 seconds. Anyone can experience a work accident, including online motorbike taxi drivers [1].

The growth of online transportation has changed how people live. Online drivers are one of the jobs in informal employment that offer online transportation in the form of services like passenger delivery, food ordering, and delivery of goods with extremely high mobility, making

online driver's a group at high risk of accidents and occupational diseases but typically receiving insufficient health care. As a result, occupational health initiatives for online motorcycle taxi drivers must be delivered by, for, and from the group of workers themselves. Activities include giving supportive, preventative, and straightforward medical care, such as emergency first aid and first aid for illnesses. Promotive and preventative actions are taken to alter employee behavior to lower or completely eliminate the risk of accidents and occupational diseases and enhance employee health. One of them is the

\* Corresponding author.

E-mail address: nurrohmah@fkm.unmul.ac.id (Nur Rohmah)

This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>)

clean living behavior and lifestyle of online drivers.

The introduction of online motorbike taxis, a convenient and effective form of transportation, has transformed Indonesian society. The issue revealed that 58,715 cases, or 79 percent, of online drivers, were involved in accidents in 2017 [2]. Previous studies discovered a connection between online drivers' driving attention and accidents [3]. The health of the driver is one of the causes of the high rate of accidents. According to Rosandy [4], there is a correlation between accident experiences, attitudes, and perceptions and driving safety behavior. Drivers who drive while smoking also have a higher risk of accidents and occupational illnesses [5].

The behavior and lifestyle of the driver such as drinking alcohol and taking certain medications are one of the causes of accidents in motorbike drivers [6]. Likewise, not having the habit of having breakfast and adequate sleep time will cause difficulty concentrating while driving.

Online drivers are a job that carries passengers, therefore performance at work is a must. Clean and healthy living behaviors are one of the things that must be considered when working. Healthy driving behaviors are to the recommendations of the Ministry of Health of the Republic of Indonesia [7] among them are consuming eating vegetables, getting enough sleep, not consuming drugs and alcoholic beverages, checking vehicles, and always checking the check existing vehicles.

Drivers who are transporting passengers must appear clean. For the comfort and safety of both themselves and their passengers, living a clean lifestyle is essential. However, Indonesia is currently lacking this relevant research. The research aimed to investigate how online drivers' behaviors of living a clean and healthy lifestyle related to vehicle accidents.

## 2. Methods

### 2.1. Population

In quantitative research with a cross-sectional methodology, a sample size of 350 respondents was obtained from 2,850 online motorcycle drivers in Samarinda.

### 2.2. Measurement tool

Validity and reliability tests have been conducted on the research questionnaire. Fill out the informed consent form as a respondent in the study before filling out the Google Forms to complete research questionnaires with five enumerators (research assistant) to prevent research bias.

### 2.3. Data collection

A purposive sampling method is used, and the following rules will apply: A minimum of three years since joining *Gojek* (one of the online application provider drivers), Have a card that designates them as an active member, and live in Samarinda City.

### 2.4. Data Analysis

Cramer's V test, Chi-Square test, and Fisher test with 95% CI was used to examine the data. There are five online driver collection locations visited to collect data. Five enumerators assisted the researchers in filling out the questionnaire.

### 2.5. Ethical Clearance

The study instrument given with number 112 / KEPK-FK / VII / 2022 has received an Ethics permit authorization from the Ethics Commission of the Faculty of Medicine, Mulawarman University.

## 3. Results

Characteristics of Respondents as for the results of the univariate analysis in this study related to the characteristics of respondents, they are presented in the following table:

Table 1, we can see how the characteristics of online drivers, the majority of them are men, where the work as a driver in male dominance can be understood because this job requires physical restraint. The median age of online drivers is 37.04 years old, which is a productive age in employment. Marital status of 74.6% is married, where the breadwinner is in meeting household needs. As many as 65.7% of the respondents' last education was junior high school. The level of secondary education became the dominance of the respondent's education level by 65.7%.

Table 1. Characteristics of respondents

Variable	Frequency (n = 350)	Percentage (%)
<b>Age</b>	Mean 37.04 ± 9.407	
<b>Gender</b>		
Male	311	88.9
Female	39	11.1
<b>Marital status</b>		
Unmarried	69	19.7
Married	261	74.6
Divorced	20	5.7
<b>Educational level</b>		
Elementary	15	4.3
Junior high school	46	13.1
Senior high school	230	65.7
Bachelor	23	6.6
Undergraduate	35	10
Master	1	0.3
<b>Employment Status</b>		
Keep driving for <i>Gojek</i> (job in <i>Gojek</i> only)	330	94.3
Private employees (double job in private sector)	12	3.4
Self-employed (for example entrepreneur, farmer, etc.)	18	2.3
<b>Status of Residence</b>		
Live your own house	86	24.6
Living with Family	158	45.1
Live with Brothers/Hitchhiking	9	2.6
Living in a Rented/Rented house	97	27.7

Table 2. Clean and healthy living behavior (terms in Indonesia is *Perilaku Hidup Bersih dan Sehat (PHBS)*).

Variable	Frequency	%
<b>Smoking status</b>		
Smoking	190	54.3
No smoking	160	45.7
<b>Smoking Places</b>		
In-House	12	6.3
Outdoors	178	93.7
<b>Number of cigarettes smoked in a day</b>		
Less than 10 bars/day	86	45.3
10 – 20 bars/day	85	44.7
More than 20 bars/day	19	10
<b>Breakfast</b>		
Yes	283	80.9
No	67	19.1
<b>The number of meals fast food in a week</b>		
Less than 3 times	280	80
More than 3 times	70	20
<b>The daily meal menu consists of Vegetables, Side Dishes and Rice</b>		
Almost never	2	0.6
Sometimes	62	17.7
Quite often	62	17.7

Table 2. Clean and healthy living behavior (terms in Indonesia is *Perilaku Hidup Bersih dan Sehat (PHBS)*).  
(cont.)

Variable	Frequency	%
Often	121	34.6
Almost all the time	103	29.4
<b>Average nighttime sleep</b>		
< 5 hours	45	12.9
> 7 hours	305	87.1
<b>Number of exercises in a week</b>		
< 5×	326	93.1
> 5×	24	6.9
<b>Duration of exercise in a day</b>		
< 30 minutes	245	70
30 – 60 minutes	79	22.6
> 60 minutes	26	7.4
<b>Coffee</b>		
Yes	261	74.6
No	89	25.4
<b>The average coffee drinks in a day</b>		
One cup	160	61.3
More than one cups	101	38.7
<b>Drinking Alcohol</b>		
Yes	9	2.6
No	341	97.4
<b>The amount of drinking alcohol in a week</b>		
one	9	100
<b>Consumption of certain drugs</b>		
Yes	29	8.3
No	321	91.7
<b>Washing hands before work</b>		
Never	4	1.1
Almost never	9	2.6
Sometimes	81	23.1
Quite often	55	15.7
Often	106	30.3
Almost all the time	95	27.1
<b>Washing hands after work</b>		
Never	1	0.3
Almost never	3	0.9
Sometimes	67	19.1
Quite often	55	15.7
Often	115	32.9
Almost all the time	109	31.1
<b>Sources of drinking water at work</b>		
Refillable water	138	39.4
Well water	3	0.9
Water	33	9.4
Mineral water	176	50.3
<b>Using PPE completely</b>		
Never	20	5.7
Almost never	16	4.6
Sometimes	38	10.9

Table 2. Clean and healthy living behavior (terms in Indonesia is Perilaku Hidup Bersih dan Sehat (PHBS). (cont.)

Variable	Frequency	%
Quite often	12	3.4
Often	119	34
Almost all the time	145	41.4
<b>Washing PPE</b>		
Never	2	0.6
Almost never	14	4
Sometimes	85	24.3
Quite often	8	2.3
Often	182	52
Almost all the time	59	16.9
<b>Get a safety talk before work by a Supervisor</b>		
Never	96	27.4
Almost never	53	15.1
Sometimes	126	36
Quite often	6	1.7
Often	44	12.6
Almost all the time	25	7.1

Table 3. Relationship of clean and health behavior with occupational accidents.

Variable	Work Accidents				Total		p-value
	Yes		No		N	%	
	n	%	n	%			
<b>Use of PPE at Work</b>							0.008
Obey	44	30.3	101	69.7	145	100	
Not Obey	91	44.4	114	55.6	205	100	

As many as 94.3% of respondents are permanent workers within Gojek only as a driver.

Table 2, Clean and healthy living behaviors at work in online drivers consist of several indicators. There was smoking behavior in online drivers at 54.3% and the rest were not smoking. The type of cigarette that was widely consumed by respondents was white cigarettes at 68.9%. Breakfast habits of 80.9% of respondents who did it every morning. 87.1% had more than 7 hours of sleep. Another habit is the habit of frequently washing hands before and after work about 30%. Only 41.4% of respondents always use PPE while driving. Only 7.1% of safety talk habits were always followed by respondents.

Table 3, related to Chi-Square test with 95% CI, shows a relationship between clean and healthy living habits, namely the use of PPE when

working with accidents. Compliance with the use of PPE has a relationship with work accidents.

Table 4, using Cramer V Test, related to differences in characteristics among accident events in respondents, insurance ownership of drivers has significant correlation (*p-value*: 0.009) with accident incidents.

#### 4. Discussion

The discussion related to clean and healthy living behaviors in online riders consists of several points. The first point is healthy living behaviors in the workplace such as breakfast, balanced eating menus, adequate sleep, drinking water, washing hands, using PPE, and participating in safety talk activities before work. The second point is the lifestyle carried out by respondents such as smoking behavior,

Table 4. Differences in characteristics among accident events in respondents (N=350).

Variables	Frequency (n = 350)	Percentage (%)	Accident incidents		p value
			yes	no	
<b>Age</b>					
< 37 years	37.04 ± 9.407		62 (34.4)	118 (65.5)	0.103
≥ 37 years			73 (42.9)	97 (57.1)	
<b>Gender</b>					
Male	311	88.9	123 (39.5)	188 (60.5)	0.288
Female	39	11.1	12 (30.8)	27 (69.2)	
<b>Marital status</b>					
Unmarried	69	19.7	30 (43.5)	39 (56.5)	0.323
Married	261	74.6	100 (38.3)	161 (61.7)	
divorce	20	5.7	5 (25)	15 (75)	
<b>Educational history</b>					
Elementary	15	4.3	7 (46.7)	8 (53.3)	0.315
Junior high school	46	13.1	13 (28.3)	33 (71.7)	
Senior high school	230	65.7	88 (38.3)	142 (61.7)	
Diploma	23	6.6	12 (52.2)	11 (47.8)	
Undergraduate	35	10	14 (40)	21 (60)	
Postgraduate	1	0.3	1 (100)	0 (0)	
<b>Status of Residence</b>					
Living alone	86	24.6	29 (33.7)	57 (66.3)	0.362
Living with nuclear family	158	45.1	69 (43.7)	89 (56.3)	
Living with extended family	9	2.6	3 (33.3)	6 (66.7)	
Living in rented/rental house	97	27.7	34 (35.1)	63 (64.9)	
<b>Motorcycle ownership status</b>					
Full	269	76.9	99 (36.8)	170 (63.2)	0.215
Credit	81	23.1	36 (44.4)	45 (55.6)	
<b>Insurance Ownership</b>					
BPJS Employment	247	70.6	107 (43.3)	140 (56.7)	0.009
Private Insurance	17	4.9	5 (29.4)	12 (70.6)	
Do not Have Insurance	86	24.6	23 (26.7)	63 (73.3)	
<b>Smoking status</b>					
Smoker	190	54.3	68 (35.8)	122 (64.2)	0.244
Non smoker	160	45.7	67 (41.9)	93 (58.1)	
<b>Breakfast behavior</b>					
Yes	283	80.9	104 (36.7)	179 (63.3)	0.150
No	67	19.1	31 (46.3)	36 (53.7)	
<b>Alcohol consuming behavior</b>					
Yes	9	2.6	3 (33.3)	6 (66.7)	0.744
No	341	97.4	132 (38.7)	209 (61.3)	
<b>Fully wearing personal protective equipment</b>					
Never	20	5.7	6 (30)	14 (70)	0.06
Almost	16	4.6	7 (43.8)	9 (56.3)	
Sometimes	38	10.9	20 (52.6)	18 (47.4)	
Quite often	12	3.4	4 (33.3)	8 (66.7)	
Often	119	34	54 (45.4)	65 (54.6)	
Almost all the time	145	41.4	44 (30.3)	101 (69.7)	
<b>Get a safety talk before work by a Supervisor</b>					
Never	96	27.4	36 (37.5)	60 (62.5)	0.136
Almost	53	15.1	22 (41.5)	31 (58.5)	
sometimes	126	36	52 (41.3)	74 (58.7)	

Table 4. Differences in characteristics among accident events in respondents (N=350). (cont.)

Variables	Frequency (n = 350)	Percentage (%)	Accident incidents		p value
			yes	no	
Quite often	6	1.7	5 (83.3)	1 (16.7)	
often	44	12.6	13 (29.5)	31 (70.5)	
Almost all the time	25	7.1	7 (28)	18 (72)	
<b>Night sleep duration</b>					
< 5 hours	45	12.9	15 (33.3)	30 (66.7)	0.439
> 7 hours	305	87.1	120 (39.3)	185 (60.7)	

consuming fast food, exercise, drinking coffee, alcohol, and taking certain medications. In this study, clean and healthy living behaviors were carried out by respondents. There is a relationship between clean living behavior and lifestyle related to the occurrence of accidents while working.

#### 4.1. Clean and healthy living behaviors

Breakfast is an increase in concentration at work. Work performance decreases with the lack of breakfast in the morning, in addition to the quality of adequate sleep, which is more than 7 hours a day [8]. In this study, eating habits in respondents, 80.9% of them did breakfast. The selection of a balanced nutrition menu makes the nutritional needs of workers well met. Good nutrition can increase productivity at work [9]. This is in line with this study, where the consumption behavior of a balanced menu consisting of vegetables, fruit, and carbohydrates frequently and over time respondents consumed, 24.6% and 29.4% respectively. Drinking water needs in informal sector workers such as online drivers must meet the daily amount of drinking water, The European Association of Urology [10] recommends daily water intake of at least 2.5 L/day. In this study, it was found that respondents' drinking water sources were obtained from refillable drinking water, which was 39.4% and bottled drinking water was 50.3%. Drinking water sources must meet water quality standards, namely bacteriological, chemical, radioactive, and physical [11].

Using PPE with an accident, in work accidents, the use of PPE is very important in maintaining the safety and security of workers. In

this study, the incidence of accidents in respondents had something to do with compliance in using PPE while driving, as many as 27.4% of respondents did not use PPE in driving. This is in line with the research [12], where it was found that work accidents occurred in workers who were low in the use of PPE while working. This shows that the use of PPE is very important to protect workers from accidents and minimize disability [13].

Following the safety talk with the incidence of accidents in the study, there was no connection with the incidence of accidents while working. This can be possible because of several factors, including because this respondent works in the informal sector where activities such as safety talk before work are not a must. But other studies of safety talk culture before work are very beneficial for workers [14] states that the presence of safety talk before work will prevent injuries to workers. Another study found the relationship between accidents and safety talk for workers before carrying out work activities and awareness of work accident prevention behaviors [15, 16]. Other research shows that safety awareness This shows that it shows that it is important that companies must do in providing safety talk time for employees before carrying out their work activities as an effort to increase worker awareness in preventing work accidents. One of the good work cultures carried out as an effort to promote health in the workplace is to routinely carry out safety talks before work, this is one of the control efforts for workers [17]. In this study, it was found that respondents stated that they had never participated in safety talk before work as much as 27.4%, and the rest they

stated that sometimes, once, often and always followed the safety talk held by their supervisors.

Shimura et al. [8] investigated the health impact of sleep on productivity in a sample of working adults in Japan where poor sleep quality resulted in decreased productivity at work. Similarly, sleep behavior in respondents in this study, as many as 12.9% of respondents had less than 5 hours of sleep per day. This will have an impact on their productivity at work and have the risk of accidents at work [18].

The habit of washing hands as well as work and after work is a recommendation that must be obeyed by all communities. Especially in the new normal period, the impact of Covid-19, where hand washing is one of the health protocols that must be followed. Research related to handwashing habits during the Covid-19 pandemic has been adhered to by many drivers. Handwashing behavior in online motorists during covid-19, as many as 98% of respondents washed their hands with soap and hand sanitizer. This shows that online drivers have clean and healthy living behaviors [19]. This is in line with this study where the habit of washing hands before and after work has been used by respondents, only about 1% of respondents do not practice the habit of washing their hands.

It can be concluded that clean and healthy living behaviors in online drivers in the workplace have been almost implemented by workers, especially about the behavior of compliance with the use of PPE.

#### 4.2. Lifestyle

Smoking behavior has become one of the lifestyles of the people. Research from the Indonesian Ministry of Health in 2018 showed that men are dominant in smoking behavior, as many as 47.3% are active smokers every day [20]. This is consistent with the study, where 54.3% of participants were current smokers. This figure is higher than the country's average of 47.3%. By 93.7%, they smoke primarily outside the home, which might be interpreted as meaning that one of the locations they smoke is at work or while driving. The tobacco use rate was 45.3%, with less than 10 cigarettes being smoked per day.

When considering nicotine dependence, the low group is considered to be less than 10 cigarettes smoked each day [21].

Accidents occur in those riding motorcycles that have accidents usually with alcohol disorders associated with younger age, driving at the end of the week, riding at night and not having a driving license [6]. In this study, there was a relationship between smoking and drinking alcohol. Where smoking and drinking alcohol as complementary in smoking behavior as found in research by [22] that smoking and alcohol are indeed interrelated [23].

Research in Canada, found that the number of fast food outlets is related to the consumption of fast food [24]. This is consistent with the study, where respondents are online drivers who offer fast food ordering as one of their services. As a result, this also influences respondents' fast food consumption, with up to 20% of them consuming it more than three times each week. When it comes to the sports they participate in, as many as 93.1% of respondents have less than 5 sports per week and less than 30 minutes of daily exercise. Fast food consumption combined with inactivity will lead to health issues, including an increased risk of obesity [25].

Research related to coffee consumption, it was found that coffee can increase a person's alertness [26], this is in line with this study, where as many as 74.6% of respondents drank coffee with an average of one cup per day (61.3%). Caffeine is known to be addictive and has a positive effect on the body. Low doses of 400 mg for people such as increased alertness, increased excitement, peace and joy [27].

In this study, the consumption of drugs carried out by respondents was related to diseases suffered such as hypertension, cholesterol, and diabetes drugs. Only about 8.3% of respondents consume these drugs. The influence of taking certain medications while driving will indeed cause side effects such as drowsiness.

#### 4.3. The relationship of healthy behavior with the incidence of accidents at work

The existence of a positive work environment relationship can improve compliance with the use

of PPE [28], likewise, in this study, the relationship between clean and healthy living behaviors and accident events in this study was in the compliance variable in using PPE, namely with a *p value* = 0.008. This can be explained, namely, when compliance with using PPE is carried out properly, it can minimize the injury severity of accidents. Including helmet use was protective for severe injuries [29]. Another research was showed about the result identification that a total of 17 significant correlations between behavior and condition factors and 30 distinguished key risk factors that highly impacted on the determination of accident 31 types and injury severity [30].

Smoking status with the incidence of accidents, in this study there was no relationship between smoking status and the incidence of accidents, this is in line with the study [31] where there is a relationship of active smokers with the incidence of accidents compared to those who do not smoke. However, there is no relationship between gender and smoking behavior in the event of an accident, that is, there is no connection for female respondents [32].

However, some variables of clean living behavior and lifestyle such as alcohol consumption, adherence to using PPE and attending safety talks in male respondents have something to do with smoking behavior, in contrast to female respondents only in the same alcohol consumption as male respondents, the rest of the morning meal variables have a relationship with smoking behavior. in this study, female respondents who smoked were 5.8%.

## 5. Conclusions

Online motorcycle taxi drivers have clean and healthy lifestyle in Indonesia that is directly related to safety at work is the compliance of using PPE in work. In addition to adherence of using PPE, clean and healthy living behaviors in online drivers there are positive behaviors such as sleeping hours, breakfast habits, hand washing habits, and exercise related to minimize the injury severity of accidents. However, smoking and drinking alcohol behaviors are still encountered.

## Recommendations

The respondent's compliant use of PPE while driving is their health-related driving behavior. This report includes suggestions, such as the requirement that businesses hold safety briefings before the start of workdays and that online drivers are informed of the use of personal protective equipment at work. The research outcomes will assist the Gojek Company and Health Services to prevent unsafe acts of workers by eliminating the associated unsafe working conditions and vice versa.

## Acknowledgments

Thank you for the 2022 Higher Education Excellence Basic Research Grant (PDUPT) from the Ministry of Research, Technology and Higher Education with contract number: 457/UN17.L1/HK/2022.

## References

- [1] World Health Organization [WHO]. Global status report on road safety 2018. [updated 2018 Jun 17; cited 2022 Sep 19]. Available from: <https://www.who.int/publications/i/item/9789241565684>.
- [2] Simamora. Menhub Minta DPR Setujui Regulasi Aturan Ojek Online. [updated 2018 May 28; cited 2022 Sep 19]. Available from: <https://kumparan.com/kumparanbisnis/menhub-minta-dpr-setujui-regulasi-aturan-ojek-online/full>.
- [3] Muin M, Rohmah N. Kewaspadaan Berkendara Dan Kecelakaan Kerja Pada Pengemudi Ojek Online Driving Awareness and Workplace Accident Among Motorcycle Taxi Drivers. *Jurnal Ilmu Keperawatan Komunitas*. 2021; 4(1): 19-24. doi: 10.32584/jikk.v4i1.1001
- [4] Rosandy B. Faktor yang Berhubungan dengan Perilaku Safety Riding pada Ojek Online Jenis X di Kota Samarinda. *Fakultas Kesehatan Masyarakat, Universitas Mulawarman*; 2019.
- [5] Ifroh R, Setyowati D, Asrianti T, Rahman W. Edukasi Upaya Pencegahan Penularan Covid-19 *Fakultas Kesehatan Masyarakat. Samarinda*; 2020.
- [6] Kuo YC, Chen LY, Chang HM, Yang TW, Huang MC, Cheng WJ. Different demographic and drinking profiles of motorcyclists and car drivers with the first-time offense of

- driving/riding under the influence of alcohol. *Accid Anal Prev.* 2020; 134: 105330. doi: 10.1016/j.aap.2019.105330
- [7] Kementerian Kesehatan Republik Indonesia. *Perilaku Sehat dalam Berkendara Jakarta 2012* [cited 2022 Sep 19]. Available from: <https://promkes.kemkes.go.id/content/?p=1650>.
- [8] Shimura A, Sugiura K, Inoue M, Misaki S, Tanimoto Y, Oshima A, et al. Which sleep hygiene factors are important? comprehensive assessment of lifestyle habits and job environment on sleep among office workers. *Sleep Health.* 2020; 6(3): 288-98. doi: 10.1016/j.sleh.2020.02.001
- [9] Salawangi ASE, Aslam M. Status Gizi, Asupan Energi dan Produktivitas Kerja pada Pekerja PT. Propack Kreasi Mandiri Cikarang. 2020; 22(2): 86-93.
- [10] Türk C, Donaldson JF, Neisius A, Petrik A, Seitz C, Skolarikos A, et al. Bladder Stones [updated 2020; cited 2022 Sep 19]. Available from: <https://uroweb.org/guideline/bladder-stones/>
- [11] Zahra SF. Kepastian Hukum Mengenai Kehigienisan Air Minum Isi Ulang Sebagai Upaya Perlindungan Konsumen Berdasarkan Undang-Undang Nomor 8 Tahun 1999 dan Peraturan Menteri Kesehatan Nomor 43 Tahun 2014 (Studi Kasus Depot Air Minum “Shaffin Water” di Kota Tebing Tinggi). Universitas Sumatera Utara; 2021.
- [12] Sehsah R, El-Gilany AH, Ibrahim AM. Personal protective equipment (PPE) use and its relation to accidents among construction workers. *Med Lav.* 2020; 111(4): 285-95. doi: 10.23749/mdl.v111i4.9398
- [13] Wang TJ, Chau B, Lui M, Lam GT, Lin N, Humbert S. Physical medicine and rehabilitation and pulmonary rehabilitation for COVID-19. *Am J Phys Med Rehabil.* 2020; 99(9): 769-74. doi: 10.1097/PHM.0000000000001505
- [14] Rae A, Provan D. Safety work versus the safety of work. *Safety Science.* 2019; 111: 119-27. doi: 10.1016/j.ssci.2018.07.001
- [15] Andriyadi Y, Setyowati DL, Ifroh RH. Hubungan Safety Promotion dengan Perilaku Aman pada Pekerja Konstruksi Proyek Pembangunan. *Jurnal Promosi Kesehatan Indonesia.* 2021; 16(2): 56-63. doi: 10.14710/jpki.16.2.56-63
- [16] Unal O. During COVID-19, which is more effective in work accident prevention behavior of healthcare professionals: Safety awareness or fatalism perception? *Work.* 2020; 67(4): 783-90. doi: 10.3233/WOR-203327
- [17] Akbar MIM, Anggara RD, Wibowo K, Adhy DS. Analisis Pelaksanaan Keamanan dan Keselamatan Kerja (K3) Dengan Metode Job Safety Analysis (JSA) Proyek Pembangunan Jembatan SiKatak Universitas Diponegoro Semarang. In: *Prosiding Konferensi Ilmiah Mahasiswa Unissula (KIMU) 4; 2020 Oktober 28; Universitas Islam Sultan Agung Semarang.*
- [18] Worley SL. The extraordinary importance of sleep: the detrimental effects of inadequate sleep on health and public safety drive an explosion of sleep research. *P T.* 2018; 43(12): 758-63.
- [19] Setyowati DL, Paramita S, Ifroh RH, Asrianti T, Fitriani E, Rahman W. Work readiness during COVID-19 among taxibike online drivers in Samarinda, Indonesia. *Int J Publ Health Sci.* 2021; 10(3): 617-28. doi: 10.11591/ijphs.v10i3.20870
- [20] Ministry of Health Republic Indonesia. *Laporan hasil riset Nasional 2018. RISKESDAS; 2018.*
- [21] Heatherton TF, Kozlowski LT, Frecker RC, Fagerstrom KO. The fagerstrom test for nicotine dependence: a revision of the fagerstrom tolerance questionnaire. *Br J Addict.* 1991; 86(9): 1119-27. doi: 10.1111/j.1360-0443.1991.tb01879.x.
- [22] Decker SL, Schwartz AE. *Cigarettes and alcohol: substitutes or complements?* Cambridge, MA: National Bureau of Economic Research; 2000.
- [23] Kock L, Shahab L, Moore G, Beard E, Bauld L, Reid G, et al. Protocol for expansion of an existing national monthly survey of smoking behaviour and alcohol use in England to Scotland and Wales: the smoking and alcohol toolkit study. *Wellcome Open Res.* 2021; 6: 67. doi: 10.12688/wellcomeopenres.16700.1
- [24] Liu B, Widener M, Burgoine T, Hammond D. Association between time-weighted activity space-based exposures to fast food outlets and fast food consumption among young adults in urban Canada. *Int J Behav Nutr Phys Act.* 2020; 17(1): 62. doi: 10.1186/s12966-020-00967-y
- [25] Mohammadbeigi A, Asgarian A, Moshir E, Heidari H, Afrashteh S, Khazaei S, et al. Fast food consumption and overweight/obesity prevalence in students and its association with general and abdominal obesity. *J Prev Med Hyg.* 2018; 59(3): E236-40. doi: 10.15167/2421-4248/jpmh2018.59.3.830

- [26] Smith AP. Caffeine, breakfast cereal and time of day: effects on alertness, encoding and recall. *Eur J Pharm Med Res.* 2020; 7(11): 51-6.
- [27] Willson C. The clinical toxicology of caffeine: A review and case study. *Toxicol Rep.* 2018; 5: 1140-52. doi: 10.1016/j.toxrep.2018.11.002
- [28] Ferdianto R, Sjoaf RZ, Kholil. Pengaruh Sikap Dan Lingkungan Kerja Terhadap Kepatuhan Penggunaan Apd Dan Pencegahan Kecelakaan Kerja Pada PT. Wastec International. *Journal of Innovation Research and Knowledge.* 2022; 1(9): 919-30.
- [29] Souto R, Corassa RB, Lima CM, Malta DC. Helmet use and injury severity among crashed motorcyclists in Brazilian state capitals: an analysis of the violence an accidents survey 2017. *Rev Bras Epidemiol.* 2020; 23(Suppl 1): e200011.SUPL.1. doi: 10.1590/1980-549720200011.supl.1
- [30] Chi S, Han S, Kim DY. Relationship between unsafe working conditions and workers' behavior and impact of working conditions on injury severity in U.S. construction industry. *J Constr Eng Manag.* 2013; 139(7): 826-38. doi: 10.1061/(ASCE)CO.1943-7862.0000657
- [31] Igarashi A, Aida J, Sairenchi T, Tsuboya T, Sugiyama K, Koyama S, et al. Does cigarette smoking increase traffic accident death during 20 years follow-up in Japan? The Ibaraki Prefectural Health Study. *J Epidemiol.* 2019; 29(5): 192-6. doi: 10.2188/jea.JE20170330
- [32] Griffin W, Haworth N, Twisk D. Patterns in perceived crash risk among male and female drivers with and without substantial cycling experience. *Transp Res Part F Traffic Psychol Behav.* 2020; 69: 1-12. doi: 10.1016/j.trf.2019.12.013

# Level of Knowledge and Risk of Osteoporosis and Their Association Among Working Women Living in Klang Valley, Malaysia

Kye Mon Min Swe \*, Hnin Pwint Phyu, Kang Shu Ting, Wendy Lau Hui Ee, Hong Kai Xin, Alicia Ho Pei Shan, Tey Fu Hao

M. Kandiah Faculty of Medicine and Health Sciences (MK-FMHS), University Tunku Abdul Rahman (UTAR), Malaysia

## Abstract

**Background:** Osteoporosis is a skeletal disorder that affects millions of people every year by causing reduced bone density and micro-architectural deterioration of the bone tissue. Women have a high risk of developing osteoporosis and well-developed knowledge and risk assessment were important in reducing the risk of developing osteoporosis through osteoprotective behaviour. The objective of this study was to find out the knowledge and risk of osteoporosis among working women living in Klang valley, and the association between the sociodemographic background of the participants with their knowledge and risk of osteoporosis.

**Method:** A cross-sectional analytical study was conducted among working women of University Tunku Abdul Rahman, Sungai Long campus who are living in Klang Valley via an online self-administrated questionnaire. A total of 158 respondents participated in this study. Validated Malaysian Osteoporosis Knowledge Tools (MKOT) were used to assess the knowledge on osteoporosis and the Osteoporosis Self-Assessment Test for Asians (OSTA) tool was used for risk assessment. The Statistical Package for Social Science (SPSS) version 22 was used to analyse the data.

**Results:** The findings indicated that there was a moderate level of knowledge among the participants with overall knowledge scores of (Mean= 58.23, and SD=17.86). The level of risk of osteoporosis among the participants was low risk with an OSTA score of (M=4.59, and SD=3.131). There was a significant association between knowledge of osteoporosis and income level and occupation of the participants ( $p < 0.05$ ): higher income level, healthcare-related occupation, and academic staff are higher knowledge of osteoporosis. The risk of osteoporosis varied significantly with the age of the participants ( $p < 0.05$ ) and there was a negative correlation between knowledge and risk of osteoporosis among the study population ( $r = -0.229$ ,  $p = 0.007$ ).

**Conclusion:** In this study, the study participants possess a moderate level of overall knowledge of osteoporosis and a low risk of developing osteoporosis. The current findings underline the importance of developing osteoporosis prevention health promotion programmes emphasised knowledge and risk of osteoporosis to increase the awareness and lower the chance of developing osteoporosis among Malaysian women.

**Keywords:** Knowledge, Risk, Osteoporosis, Working women, Malaysia

## 1. Introduction

Osteoporosis is a major health problem, especially in elderly populations and postmenopausal women, and is associated with fragility fractures at the hip, spine, and wrist. Osteoporotic hip fracture contributes to both morbidity and mortality and it has been estimated

that the cases will rise from 1.7 million in 1990 to 6.3 million that by 2050 and half of hip fractures will occur in developing countries especially in Asia [1, 2].

In Malaysia, the prevalence of osteoporosis is 24.1% [3] and there was an alarming forecast on hip fracture incidence rates in Malaysia would

\* Corresponding author.

E-mail address: kyemon@utar.edu.my (Kye Mon Min Swe)

have increased by 2050 due to increasing total number of hip fractures [4]. Due to the asymptomatic nature of osteoporosis, women who have osteoporosis are often unaware about an increased risk of sustaining a fracture. Therefore, prevention measures and screening that aid in early detection were the most cost-effective ways to reduce the number of hospital admissions due to osteoporotic fractures [4]. Therefore, this study focused on osteoporosis screening targeted at primary and secondary prevention using an osteoporosis risk assessment tool.

According to the Department of Statistics Malaysia [5], the female workforce in Malaysia has a broad age group and, estimated 35% of the local female workforce is above the age of 40 and had a substantial risk for osteoporosis because of the onset of menopause. This study observed the sedentary lifestyle of working women would predispose them to the risk of osteoporosis. Commencing prevention practices from a younger age can slow down the process of developing osteoporosis. Hence, this study will provide us with insight about the possibility of this often overlooked group getting osteoporosis [5].

The study objectives were to determine the knowledge level and risk level of osteoporosis and to find out the association between the knowledge and risk of osteoporosis among the women living in Klang Valley.

## 2. Materials and Methods

A cross-sectional analytic study was conducted on women between the ages 18 and above working at UTAR who are currently living in Klang Valley; located situated in the middle of the west coast of Peninsular Malaysia [6]. Working women were chosen as the target population in our studies due to the higher risk of osteoporosis among them. The study was conducted online and the convenience sampling method was used.

The questionnaire was adopted from the Malaysian Osteoporosis Knowledge Tool (MOKT) of the study [7]. The permission had been granted by the author of the study. There

was a total of 30 questions to assess the general knowledge, sign, and symptoms, as well as the risk factors of osteoporosis. The responses for each question were "True", "False" and "I don't know". 1 point was awarded for each correct answer, whereas no mark was granted for false or "I don't know. The overall Cronbach's alpha value of the questionnaire was 0.82. Knowledge level on Osteoporosis is classified according to the study by Chan et al. [8]. A knowledge level of less than 50% is poor knowledge, 51-69% Moderate, and more than 70% High. The questionnaire consisted of 4 sections: Sociodemographic Information of participants, Medical History, MOKT knowledge questions, and self-reported weight and age will be obtained for the OSTA assessment of risk. The information sheet and consent sheet were obtained from the participants [8].

The osteoporosis Self-Assessment Tool for Asians (OSTA) developed by World Health Organization was used to determine the risk level of osteoporosis among respondents [9]. OSTA score was a practical assessment tool for screening because it is affordable and efficient. The participants were required to self-report their weight and age. The OSTA scores were calculated using the formula:  $0.2 [\text{weight (kg)} - \text{age (year)}]$ . After calculating the OSTA score, the data were classified into 3 different categories based on the severity. Scores lower than -4 will be classified as high risk, scores between -4 and -1 fell into a medium level, and score greater than -1 were classified as low risk. OSTA had a sensitivity of 91% and a specificity of 45% [10]. Overall, the OSTA score showed high accuracy in assessing the risk of osteoporosis.

All the staffs members of UTAR were invited to participate in the study via sending email containing the google form link to questionnaires. The study obtained ethical approval from UTAR Scientific and Ethical Review Committee (SERC) and respondents' consent has been taken to participate in this study.

The data were analysed by using the software Statistical Package for the Social Sciences (SPSS) Version 22. Chi-Square test was used to analyse the significant relationship between

Table 1. Type of knowledge towards osteoporosis in each section with level of classification (N=158).

Type of knowledge	Mean, M% ± Standard deviation of the total score	Level of classification
General knowledge	67.5 (24.0)	Moderate
Sign and symptoms	58.9 (19.5)	Moderate
Risk factors	54.7 (21.6)	Moderate
Overall knowledge	58.2 (17.9)	Moderate

Table 2. Risk level based on OSTA score (N=139)

Risk level	Score range	Number, n (percentage, %)
Low level	>-1	135 (97.1)
Medium level	-1 to -4	4 (2.9)
High level	<-4	0 (0)

sociodemographic characteristics with the knowledge and risk level of osteoporosis. Pearson correlation test was used to find out the correlation between the knowledge of osteoporosis and the risk of developing it. The results that gave a p-value of less than 0.05 were considered significant and the null hypothesis was rejected.

### 3. Results

A total of 158 participants completed the questionnaires. For the OSTA risk level, 19 participants were excluded due to underlying risk factors such as a previous history of fracture, family history of osteoporosis, or underlying disease that interfere with bone metabolism and breastfeeding and 139 participants remained.

The majority of the participants were aged 36 to 55, 93 (58.9%), Chinese 74 (46.8%), Malaysian 150 (94.9%), tertiary educational level 145 (94.9%), and married 104 (65.8%). Most of the participants were middle-income level (62%) and non-healthcare professionals 134 (84.8%) and academic staff 91 (57.6%). The majority of the participants were in the range of healthy weight 57 (36.3%) and overweight 51 (32.5%), and the average BMI was 24.91 kg/m<sup>2</sup>. Most working women were young age with pre-menopause 142 (89.9%), and an average of 51.31 years old among 16 participants who had gone through menopause. The average height was 160cm, the average weight was 60 kg, and the

average age of menarche was 13 years old.

#### 3.1. Knowledge of Osteoporosis

Table 1, participants had the highest general knowledge of osteoporosis (67.5%), which is categorised into moderate levels. The knowledge of signs and symptoms and risk factors were also moderate with (58.9%) and (54.7%) respectively. The overall total score of osteoporosis was (58.2 %), which was also at a moderate level (Table 1).

#### 3.2. Risk of osteoporosis

Regarding the risk of osteoporosis majority of the participant had low risk 135 (97.1%) and the remaining was moderate risk level 4 (2.9%) on osteoporosis (Table 2).

#### 3.3. The association between sociodemographic backgrounds and knowledge of osteoporosis

Regarding the association between sociodemographic characteristics and knowledge of osteoporosis, factors such as income level per month, occupation, and job type were statistically significant with the knowledge level. Participants in higher income levels, T20 (compared to B40 and M40, p= 0.004), healthcare professionals (compared to non-healthcare professionals, p<0.001), and academic staff (compared to administrative staff, p= 0.001) had higher knowledge levels on osteoporosis (Table 3).

Table 3. Association between sociodemographic characteristics and knowledge level (N=158).

Characteristics	Knowledge level of osteoporosis, n (%)			Chi-square	
	Poor	Moderate	Good	Chi Square	p value
<b>Age</b>					
18-35	26 (48.1)	17 (31.5)	11 (20.4)	6.582 <sup>f</sup>	0.155
36-55	33 (35.3)	27 (29.0)	33 (35.5)		
>56	3 (27.3)	2 (18.2)	6 (54.5)		
<b>Race</b>					
Malay	21 (44.7)	13 (27.7)	13 (27.2)	3.300 <sup>f</sup>	0.789
Chinese	25 (33.8)	21 (28.4)	28 (37.8)		
Indian	13 (41.9)	10 (32.3)	8 (25.8)		
Others	3 (50.0)	2 (33.3)	1 (16.7)		
<b>Nationality</b>					
Malaysian	60 (40.0)	44 (29.3)	46 (30.7)	1.353 <sup>f</sup>	0.597
Non-Malaysian	2 (25.0)	2 (25.0)	4 (50.0)		
<b>Educational level</b>					
Secondary/Diploma	9 (69.2)	2 (15.4)	2 (15.4)	4.623 <sup>f</sup>	0.082
Tertiary (Degree, Master, PhD)	53 (36.6)	44 (30.3)	48 (33.1)		
<b>Income level per month</b>					
B40	22 (64.7)	7 (20.6)	5 (14.7)	15.062	0.004*
M40	34 (34.7)	32 (32.7)	32 (32.7)		
T20	6 (23.1)	7 (26.9)	13 (50.0)		
<b>Occupation</b>					
Healthcare professional	3 (12.5)	5 (20.8)	16 (66.7)	16.791	<0.001*
Non-Healthcare professional	59 (44.0)	41 (30.6)	34 (25.4)		
<b>Job Type</b>					
Academic staff	25 (27.5)	30 (33.0)	36 (39.6)	12.916	0.001*
Administrative staff	37 (55.2)	16 (23.9)	14 (20.9)		

\*Level of significant at p <0.05. Assessed using chi-square among the group, <sup>f</sup> Fisher's Exact Test, B40, subjects with household income <RM 7640; M40, subjects with household income RM 7640–15,159; T20, subjects with household income >RM 15,160.

Table 4. Correlation between overall knowledge, general knowledge, signs and symptoms, risk factors for osteoporosis.

Variable		Overall knowledge	General knowledge	Signs and symptoms	Risk factors
Overall knowledge	p	-	<0.001	<0.001	<0.001
	r		0.701**	0.806**	0.917**
General knowledge	p	<0.001	-	<0.001	<0.001
	r	0.701**		0.479**	0.506**
Signs and symptoms	p	<0.001	<0.001	-	<0.001
	r	0.806**	0.479**		0.560**
Risk factors	p	<0.001	<0.001	<0.001	-
	r	0.917**	0.506**	0.560**	

Pearson correlation test was performed. \*\*Level of significant at p <0.001. r = correlation coefficient.

Table 5. Association between sociodemographic characteristics and risk level of osteoporosis (n=139).

Characteristics	Risk of osteoporosis, n (%)		Chi-square	
	Low	Moderate	Chi Square	p value
<b>Age</b>				
18-35	47 (100.0)	0 (0.0)	21.307 <sup>f</sup>	<0.001*
36-55	83 (100.0)	0 (0.0)		
>56	5 (55.6)	4 (44.4)		
<b>Race</b>				
Malay	40 (100.0)	0 (0.0)	6.219 <sup>f</sup>	0.082
Chinese	67 (98.5)	1 (1.5)		
Indian	25 (89.3)	3 (10.7)		
Others	3 (100)	0 (0.0)		
<b>Educational level</b>			1.926 <sup>f</sup>	1.000
Secondary	1 (100)	0 (0)		
Diploma	10 (100)	0 (0)		
Tertiary (degree, master, PhD)	124 (96.9)	4 (3.1)		
<b>Income level per month</b>				
B40	32 (100)	0 (0.0)	1.320 <sup>f</sup>	0.615
M40	83 (96.5)	3 (3.5)		
T20	20 (95.2)	1 (4.8)		
<b>BMI (kg/m<sup>2</sup>)</b>			2.061 <sup>f</sup>	0.569
Underweight	8 (100)	0 (0)		
Healthy Weight	50 (94.3)	3 (5.7)		
Overweight	45 (97.8)	1 (2.2)		
Obesity	32 (100)	0 (0)		
<b>Menopause age (years)</b>			-	<0.001*
pre/perimenopausal post-	126 (100)	0 (0)		
menopause	9 (69.2)	4 (30.8)		

Level of significant at  $p < 0.05$ . Assessed using chi-square among the group, f Fisher's Exact Test, B40, subjects with household income <RM 7640; M40, subjects with household income RM 7640–15,159; T20, subjects with household income >RM 15,160.

Table 4, there were significant positive the correlation between the total knowledge score with overall knowledge of the questionnaire.

### 3.4. The relation between sociodemographic background with the risk level on osteoporosis

Sociodemographic factors such as age and menopause age were statistically significant with the risk level of osteoporosis. It was observed that participants >56 years old (compared with age 18-35 and 36-55 years,  $p < 0.001$ ) and who experienced menopause (compared with pre/perimenopausal women,  $p < 0.001$ ) had a higher risk of osteoporosis. The sociodemographic factors like race, educational level, income level per month, and BMI were not statistically significant (Table 5).

## 4. Discussion and Conclusion

The study was aim to determine the level of knowledge and risk of osteoporosis among working women, which were unprecedented in Malaysia. Since the study population in this study was mostly mental labour and had a sedentary lifestyle, this study would indicate the association and correlation between them.

### 4.1. Knowledge of osteoporosis among the participants

The overall knowledge level on Osteoporosis among working women was moderate level, which was in line with a few recent studies in Malaysia. The female literacy rate of Malaysia was (95.76%) according to global data 2021 and the studies have shown that the female population

has a moderate level of health knowledge due to certain exposure to health promotion programmes [3, 8, 11]. But the studies conducted in middle east countries found that there was a low and inadequate amount of knowledge on osteoporosis [12]. The knowledge questions were subdivided into three parts, knowledge of signs and symptoms, knowledge of risk, and knowledge of prevention of osteoporosis. The participants have moderate knowledge of the risk and prevention of osteoporosis.

In this study, over 50% of the participants were able to relate lack of oestrogen (60.8%) and early menopause (54.4%) to increasing the likelihood of osteoporosis development similar to this study a study by Cheng et al. [13] found that 42.2% of their participants knew of early menopause as a risk factor. This was comparable to a Singaporean study that saw 69.7% of their participants agreeing with that risk factor [14]. In contrast, studies done in Vietnam, Egypt, and Pakistan had a lower awareness rate of lack of estrogen and early menopause as risk factors [15-17].

#### *4.2. The risk of osteoporosis among the participants*

In this study, the majority of participants were at a low-risk level of osteoporosis (97.1%) and (2.9%) were at a medium-risk level, none of the participants were at a high-risk level. The data were contrasted with a few studies in Malaysia [10, 18-20]. These studies demonstrated a high risk of osteoporosis because the studies were done in post-menopausal women. This could be explained that most of the participants in this study were younger and had not reached the age of menopause, the median age in this study was 38 years old. The osteoporotic patients were also excluded from this study due to inaccuracy in the calculation of the OSTA score.

#### *4.3. The relation between sociodemographic background with knowledge of osteoporosis*

In this study, the educational level of the female staff were high as 145 (91.8%) were in tertiary education, however, the educational status would not affect the knowledge level on

osteoporosis. In this study, the association between total income per month, occupation, and job type was statistically significant. This was in line with the study [8] stated that income level signified participants had access to more health screening and, were given more knowledge on their health [8]. Healthcare-related jobs would equip them with knowledge of the medical field, which helps them in answering the questions, this was supported by the MOKT study. Pharmacists (81.6±9.5%) had a higher score than the osteoporotic patient (69.0±13.9%) [7]. Academic staff were the professionals in lecturing the students, therefore were more competent and knowledgeable. In the view of the fact that understanding every part of knowledge was important in the holistic approach.

#### *4.4. The relation between sociodemographic background with the risk level of osteoporosis*

In this study, the age and weight were statistically significant to the risk of osteoporosis, this was supported by few studies [18, 20]. When the age increases, the risk of getting osteoporosis also increased [21]. The results revealed that weight and risk were strongly positively correlated, in connection with the findings by WHO, 1994, when the weight increases, the risk would decrease [9].

Menopause was statistically significant with the risk of osteoporosis and was considered as the risk factor of osteoporosis because of the decreasing level of estrogen, which in turn accelerates bone degradation [22]. The race, educational level, and income level per month were not statistically significant to the risk level of osteoporosis, which was contradicting the studies which was found that Chinese population were higher risk of osteoporosis compare to Malay and Indian [18, 20].

#### *4.5. Limitations of the study*

This study is a cross-sectional study and self-reported weight was collected and there might be variation with actual weight. The recall bias on the age of menarche and menopause among female respondents also contributed to the deviation in this study.

## 5. Conclusion

The study results reveal that the overall knowledge level of Osteoporosis among participants working women living in Klang Valley was moderate and most participants were at low risk of osteoporosis according to OSTA score. This study provides data to increase the awareness and prevention measures of osteoporosis. With the use of the OSTA score, further therapeutic and treatment could be focused on the high-risk patient, which would enlighten the socioeconomic burden in society.

## References

- [1] Dhanwal DK, Dennison EM, Harvey NC, Cooper C. Epidemiology of hip fracture: Worldwide geographic variation. *Indian J Orthop.* 2011; 45(1): 15-22. doi: 10.4103/0019-5413.73656
- [2] Royal Australian College of General Practitioners [RACGP]. Osteoporosis prevention, diagnosis and management in postmenopausal women and men over 50 years of age. [cited 2022 Nov]. Available from: <https://www.racgp.org.au/getattachment/2261965f-112a-47e3-b7f9-cecb9dc4fe9f/Osteoporosis-prevention-diagnosis-and-management-in-postmenopausal-women-and-men-over-50-years-of-age.aspx>.
- [3] Leng LS, Ali A, Yusof HM. Knowledge, attitude and practices towards osteoporosis prevention among adults in Kuala Lumpur, Malaysia. *Malays J Nutr.* 2017; 23(2): 279-90.
- [4] Cheung CL, Ang SB, Chadha M, Chow ES, Chung YS, Hew FL, et al. An updated hip fracture projection in Asia: The Asian Federation of Osteoporosis Societies study. *Osteoporos Sarcopenia.* 2018; 4(1): 16-21. doi: 10.1016/j.afos.2018.03.003
- [5] Department of Statistics Malaysia. Department of Statistics Malaysia Official Portal. [cited 2022 Nov]. Available from: [https://www.dosm.gov.my/v1/index.php?r=column/cone&menu\\_id=eGUyTm9RcEVZSllm%20YW45dmpnZHh4dz09](https://www.dosm.gov.my/v1/index.php?r=column/cone&menu_id=eGUyTm9RcEVZSllm%20YW45dmpnZHh4dz09)
- [6] Rashid MFA, Ghani IA. The importance of internal migration: in the context of urban planning decision making. [cited 2022 Nov]. Available from: <https://www.researchgate.net/publication/260481175>
- [7] Lai PS, Chua SS, Chan SP, Low WY. The validity and reliability of the Malaysian Osteoporosis Knowledge Tool in postmenopausal women. *Maturitas.* 2008; 60(2): 122-30. doi: 10.1016/j.maturitas.2008.04.006
- [8] Chan CY, Subramaniam S, Chin KY, Ima-Nirwana S, Muhammad N, Fairus A, et al. Levels of knowledge, beliefs, and practices regarding osteoporosis and the associations with bone mineral density among populations more than 40 years old in Malaysia. *Int J Environ Res Public Health.* 2019; 16(21): 4115. doi: 10.3390/ijerph16214115
- [9] World Health Organization [WHO]. Assessment of fracture risk and its application to screening for postmenopausal osteoporosis. Geneva: WHO; 1994.
- [10] Koh LK, Sedrine WB, Torralba TP, Kung A, Fujiwara S, Chan SP, et al. A simple tool to identify asian women at increased risk of osteoporosis. *Osteoporos Int.* 2001; 12(8): 699-705. doi: 10.1007/s001980170070
- [11] Chan CY, Subramaniam S, Chin KY, Ima-Nirwana S, Muhammad N, Fairus A, et al. Knowledge, beliefs, dietary, and lifestyle practices related to bone health among middle-aged and elderly chinese in klang valley, Malaysia. *Int J Environ Res Public Health.* 2019; 16(10): 1787. doi: 10.3390/ijerph16101787
- [12] Saleh AM, Alahmadi AE, Jaafari AA, Al-Hussan TH, Alfaifi MA, Alammari MA, et al. Assessment of osteoporosis knowledge test among community population in Abha City, KSA. *Egypt J Hosp Med.* 2017; 69(3): 2176-80. doi: 10.12816/0041078
- [13] Cheng YT, Keshavarzi F, Junaid Farrukh M, Aly Mahmoud SSL. Assessment of knowledge, attitude and practice of Malaysian women towards osteoporosis. *Curr Trends Biotechnol Pharm.* 2020; 14(5): 55-63. doi: 10.5530/ctbp.2020.4s.6
- [14] Lulla D, Teo CW, Shen X, Loi ZBJ, Quek KW, Lis HLA, et al. Assessing the knowledge, attitude and practice of osteoporosis among Singaporean women aged 65 years and above at two SingHealth polyclinics. *Singapore Med J.* 2021; 62(4): 190-4. doi: 10.11622/smedj.2021039
- [15] Nguyen NV, Dinh TA, Ngo QV, Tran VD, Breitkopf CR. Awareness and knowledge of osteoporosis in Vietnamese women. *Asia Pac J Public Health.* 2015; 27(2): NP95-105. doi: 10.1177/1010539511423569
- [16] El-Tawab SS, Saba EKA, Elweshahi HMT, Ashry MH. Knowledge of osteoporosis among women in Alexandria (Egypt): A community

- based survey. *Egypt Rheumatol.* 2016; 38(3): 225-31. doi: 10.1016/j.ejr.2015.08.001
- [17] Bilal M, Haseeb A, Merchant AZ, Rehman A, Arshad MH, Malik M, et al. Knowledge, beliefs and practices regarding osteoporosis among female medical school entrants in Pakistan. *Asia Pac Fam Med.* 2017; 16(1): 6. doi: 10.1186/s12930-017-0036-4
- [18] Chan CY, Subramaniam S, Mohamed N, Ima-Nirwana S, Muhammad N, Fairus A, et al. Determinants of bone health status in a multi-ethnic population in Klang Valley, Malaysia. *Int J Environ Res Public Health.* 2020; 17(2): 384. doi: 10.3390/ijerph17020384
- [19] Muslim D, Mohd E, Sallehudin A, Tengku Muzaffar T, Ezane A. Performance of Osteoporosis Self-assessment Tool for Asian (OSTA) for primary osteoporosis in post-menopausal Malay women. *Malays Orthop J.* 2012; 6(1): 35-9. doi: 10.5704/MOJ.1203.011
- [20] Subramaniam S, Chan CY, Soelaiman IN, Mohamed N, Muhammad N, Ahmad F, et al. Prevalence and predictors of osteoporosis among the Chinese population in Klang Valley, Malaysia. *Applied Sciences.* 2019; 9(9): 1820. doi: 10.3390/app9091820
- [21] Ministry of Health Malaysia; Academy of Medicine; Malaysian Osteoporosis Society. Clinical guidance on management of osteoporosis 2012. [cited 2022 Nov]. Available from: <http://www.moh.gov.my>
- [22] Koda-Kimble MA, Young LY, Alldredge BK, Corelli RL, Guglielmo BJ, Kradian WA, et al. *Applied therapeutics: The clinical use of drugs.* Philadelphia: Lippincott Williams & Wilkins; 2009.

# Lower Extremity Kinematics and Kinetics During Walking: A Comparison Between Khon Masked Dancers and Non-Dancers

Zin Wai Htet <sup>a</sup>, Sunee Bovonsunthonchai <sup>a</sup>, Pagamas Piriyaprasarth <sup>a</sup>,  
Nopporn Jongkamonwiwat <sup>b</sup>, Warin Krityakiarana <sup>a, \*</sup>

<sup>a</sup> Faculty of Physical Therapy, Mahidol University, Nakhon Pathom, Thailand

<sup>b</sup> Department of Anatomy, Center for Neuroscience Research, Faculty of Science, Mahidol University, Bangkok, Thailand

## Abstract

**Background:** Khon masked dance is one of the famous Thai traditional dance that requires long-term training. One of the essential training position is performed in the squat position which can affect the walking patterns of the dancers. This study aimed to compare the lower extremity kinematics in the sagittal, frontal, and transverse planes during walking between Khon masked dancers and non-dancers.

**Method:** It used convenience sampling technique and twenty healthy males (10 Khon masked dancers and 10 healthy males) were participated in the study. Professional Khon masked dancers who had at least 5 years of dancing experience in giant or monkey role play and all participants were 20 to 40 years' healthy male with body mass index (BMI) of 18.5 – 30 kg/m<sup>2</sup>. Participants walked at a self-selected speed on the 9-meter walkway in the 3D motion analysis setting located at Faculty of Physical Therapy, Mahidol University.

**Results:** Kinematics variables included the angles of pelvic tilt, obliquity, and rotation, hip and knee flexion/extension, adduction/abduction, internal rotation/external rotation, and ankle dorsiflexion/plantarflexion were collected and evaluated. Kinetics variables including anterior, posterior, medial, lateral, and vertical forces were also monitored. Data were then statistically analyzed between professional dancers and non-dancers by using the independent sample t-test with a level of significance of  $p < 0.05$ . There was no significant difference in all testing variables between the two groups of participants. However, Khon masked dancers revealed higher anterior pelvic tilt angle at terminal swing and external rotation angle at terminal stance, hip flexion angle at mid-swing, knee flexion angle at loading response, and adduction at mid-swing. Gait pattern in Khon mask dancers demonstrated increased pelvic anterior tilt in conjunction with the increased lumbar lordosis.

**Conclusion:** This study demonstrated that long-term Khon training was not significantly affected in the gait patterns of the dancers. However, more sample size is still necessary for the future to investigate a clearer picture of gait alteration in Khon masked dancers.

**Keywords:** Khon masked dancers, kinematics, kinetics, gait analysis.

## 1. Introduction

Human gait is a complex process correlated with many systems of the body such as the central nervous system, peripheral nervous system, musculoskeletal system, and cardiopulmonary system [1]. If some parts of the system have alternations or limitations, it can lead to a change in the gait pattern of the person [2]. Therefore,

gait analysis is an important diagnostic tool for monitoring, preventing injuries, and rehabilitation. Moreover, it can be used in sport science to improve the techniques and performances of athletes [3]. Kinematic and kinetic variables are used in various actions including gait analysis. Kinematics investigates the movement of the body through space. The position and movement

\* Corresponding author.

E-mail address: warin.kri@mahidol.edu (Warin Krityakiarana)

of each body segment are usually transformed into angular displacements of joints over time [4]. Kinetics investigates the forces involved in producing the movements necessary for walking. These are usually calculated from ground-reaction forces (GRF) that are mapped upwards through lower limbs and joints [5]. GRF is widely used in gait and foot deformities [6, 7].

Differences in the gait pattern have been demonstrated between dancers and non-dancers, especially in ballet dancers. Dancers have different gait patterns when compared with non-dancers because they have greater strength, stability, postural control, and flexibility than the non-dancers and they have long-time and repeated training to be professional [8]. It has been reported that dancers have similar characteristics to people with flatfoot who have decreasing medial arch of the foot during normal walking [9]. Decreased ankle plantarflexion during loading response showed in dancers because of the flat-arched foot which occurs due to the excessive position of the foot during dancing movements [10]. The altered foot alignments might fail to absorb forces applied to the limb during the gait cycle. Moreover, dancers also have greater hip external rotation to maintain dancing position. If hip external rotation is limited to achieving a dancing position, they would apply additional external torque to the thigh and foot relative to the leg and this can cause foot pronation and hypermobility of the first metatarsal joint [11].

The greater medial foot pressure during walking, from flatten of medial arch, can cause higher foot pronation that leads to excessive internal rotation of the tibia, knee valgus, internal rotation of the femur, and increase ante-version of pelvic in the dancers [12]. It results in increased lumbar lordosis and hyperextension in hallux valgus which can affect the kinematic variables of the lower extremities of the dancers [10, 12]. The decreased plantarflexion during loading response may be compensated by reduced knee extension and increased pelvic rotation. Dancers have greater knee flexion in the swing phase and greater hip abduction in pre-swing, greater dorsiflexion in terminal stance, and greater total

pelvic tilt in all three planes. These can change foot pressure and tend to affect the gait patterns of the dancers [13, 14]. Altered foot alignments may fail to absorb forces applied to the limb during the gait cycle. For the kinetic variables of gait in dancers, the greater medial shear force is caused by the pronated foot of the dancer who had more eversion of the forefoot during the pre-swing phase [15].

Khon dance is a popular dance among Asian countries and it is the national trademark of Thailand. Dancers have to wear colorful masks based on their dancing characters. The characters are divided into giant, monkey, god, and angel and most of the story is about battles between giants and monkeys. The foot movements of Thai dance are generally slow and they emphasize to get delicate and graceful movements of the arms and hands [16]. Giants and monkey role-play dancers require more intensive lower limb activities than other characters such as god and angel [3]. Especially, dancers always keep deep square squat position with knee flexion, separating foot toe-out and landing with a single leg slapping on the floor [3, 17, 18]. Previous studies demonstrated that Khon dancers had greater strength, flexibility and dynamic postural control than non-dancers [8, 19]. Stretching exercises like squaring the thigh, another person pressing the dancer 'thigh to be the right angle, and keeping deep square squat position may lead to increase muscle flexibility and strength of the lower extremities but the dancing style is delicate [16]. Moreover, sensorimotor function in dancers is improved because dancing is performed in the upright position and requires long period of unilateral stance that can enhance balance and postural control [13, 20]. The effect of Khon dance training can improve motor control and postural control but there was no significant effect on body composition [3, 17, 18].

Although there are some articles related with Khon dancers, especially in balance and postural control, no one focused on gait analysis for professional Khon masked dancers when performing normal walking activity. Therefore, I would like to perform the research for "Lower Extremity Kinematics and Kinetics During

Walking: A Comparison between Khon Masked Dancers and Non-Dancers". This study aimed to compare the lower extremity kinematics and kinetics in the sagittal, frontal, and transverse planes during walking between Khon masked dancers and non-dancers. As earlier mentioned, dancers' lower limbs are placed in a fundamental position for the specific dancing character for a long period so they may be deferred from non-dancers not only in the musculoskeletal system but also in the gait pattern.

## 2. Methods

### 2.1. Participants

This study is an exploratory study using a cross-sectional design to compare the kinematic and kinetic variables between Khon dancers and non-dancers. The convenience sampling technique was used in this study. Twenty healthy males participated in this study (10 Khon masked dancers and 10 healthy males) after reading and signing a consent form that approved by Mahidol University-Central Institutional Research Board (MU-CIRB 2021/484.2211). Dancers were recruited from the College of Dramatic Arts (Bunditpatanasilpa Institute) Salaya, Nakhon Pathom province, Thailand who had at least 5 years of dancing experience in giant or monkey role play. All dancers practiced 5 days a week and on average 3 hours per day. The study setting was in Motion Analysis Laboratory located at Faculty of Physical Therapy, Mahidol University. The control group had no experience in Khon dance and professional level at any kind of sport activities. Inclusion criteria for both groups were 20 to 40 years' healthy males. All eligible participants were excluded from the study if they have surgeries or a history of injury within the prior 6 months of study, painful musculoskeletal conditions in lower extremities, and asymmetrical leg length (leg length discrepancy) of at least 1 cm.

### 2.2. Procedure

The participants were instructed to kick a ball, pick the erasers, and draw the figure of eight to determine the dominant leg. The tape measure was used to identify the limb length discrepancy.

Then, all participants underwent anthropometric measurements consisting of body weight, height, leg length, and ankle and knee widths to calculate the joint center. Walking trials were performed on a 9-meter walkway which had embedded two force plates for recording kinetic data with a sampling frequency of 1000 Hz. Kinematic data were obtained using Vicon MX (Vicon 2.10.3, Oxford Metrics Group, London, UK) with 10 infra-red cameras (Vantage camera, sampling frequency 120 Hz) and the low pass Butterworth filtering method (6 Hz used for kinematics variables and 25 Hz for kinetics variables). Sixteen reflective markers were attached to lower limbs according to the Plug-In-Gait model.

Before data collection, participants stood on one force plate for 30 seconds to do the static calibration of the system. During resting stance, they stood barefoot and maintained a horizontal gaze, arms and hands hung vertically like the anatomical position (Fig. 1). All participants had to perform five successful walking trials with self-selected walking speed. During trials, they had to look at a target placed at about 160-170 cm above the floor on the wall at the end of the track to prevent adjusting walking style around the force plate [21].

### 2.3. Data Analysis

Data analysis was performed in the gait laboratory at the Faculty of Physical Therapy at Mahidol University. The data were exported to Microsoft Excel for analysis. Data will be averaged from the three successive trials, and normalized to 100% of the gait cycle. The maximum values for kinematic variables and GRF were determined in the three anatomical planes for further use in statistical analysis. Maximal angular motion of lower limbs and pelvic in all three planes during the gait cycle were calculated for the following angles: the maximal ankle plantar/dorsiflexion in the sagittal plane; the maximum flexion/extension of joint angle in the sagittal plane, adduction/abduction in the frontal plane, and internal/external rotation in the transverse plane for hip and knee during the stance and swing phase of the gait cycle; the maximum pelvic anterior/posterior tilt in the

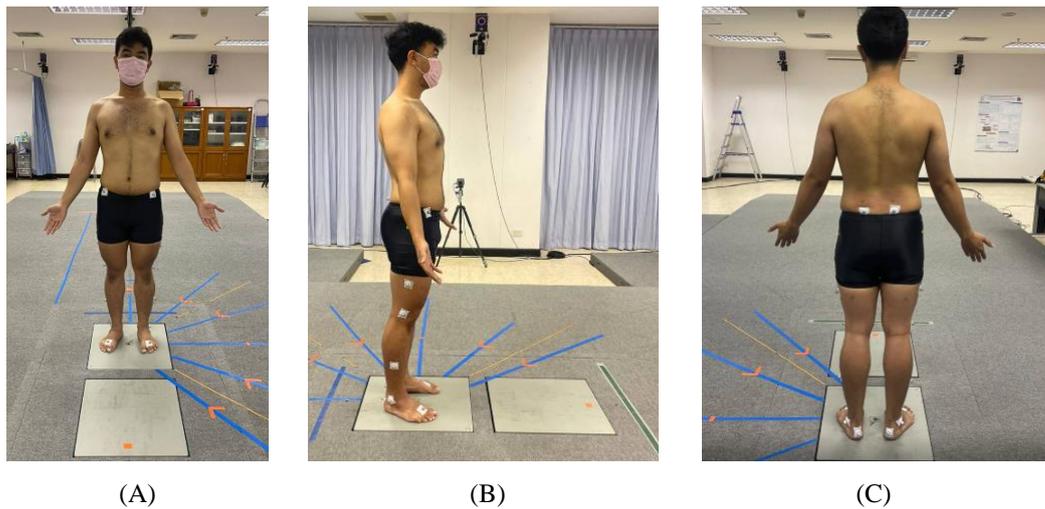


Fig. 1. Static calibration of the system at gait laboratory. Lower extremities Plug-In-Gait model (A) anterior view, (B) lateral view, and (C) posterior view.

Table 1. Anthropometric data of participants

Anthropometric measurements	Dancer group (n= 10)	Non-dancer group (n=10)	p-value
Age (years)	21.4 ± 1.6	20.3 ± 0.5	0.06
Weight (Kg)	64.8 ± 13.1	67.6 ± 10.2	0.59
Height (cm)	169.1 ± 5.4	174.6 ± 7.4	0.07
BMI (kg/m <sup>2</sup> )	22.5 ± 3.5	22.1 ± 2.2	0.75

Note: All values are mean ± standard deviation (SD).

sagittal plane, pelvic obliquity in the frontal plane, and pelvic rotation in the transverse plane. Kinetic variables were analyzed from GRF data in all three planes (vertical, anterior-posterior, and medial-lateral). GRF variables were normalized with body weight. All kinematic and kinetic variables were presented as mean and standard deviation (mean ± SD) for comparison between the two groups.

#### 2.4. Statistical Analysis

All statistical analysis was evaluated by using SPSS software (SPSS Statistics for Window, Version 22, USA). The mean and standard deviation (SD) for all variables were calculated with the average of three successive trials. P values less than 0.05 were considered significant. Only the right

dominant leg was used for data analysis. Descriptive statistics were used for the demographic factors such as age, height, weight, BMI, year of dancing experience, and amount of training time for both groups. Shapiro-Wilk test was used to test the data normality. The independent sample t-test was used to determine the differences in gait kinetic and kinematic variables between professional Khon dancers and non-dancers.

### 3. Results

The anthropometric data of the two groups are shown in Table 1. The dancer group had an average of  $7.8 \pm 1.69$  years of dancing experience. No significant difference in all testing variables between the two groups of participants in Table 2 for kinematic and Table 3 for kinetic variables.

Table 2. Kinematic joint angular displacements (mean and SD) for the dancer and non-dancer groups in three planes of movement.

Plane	Variables	Dancer	Non-dancer	p-value
		Mean $\pm$ SD	Mean $\pm$ SD	
<b>Sagittal</b>	maximum pelvic tilt anteriorly at TSw	8.5 $\pm$ 4.6	6.7 $\pm$ 4.6	0.41
	maximum hip extension angle at TSt	-9.7 $\pm$ 4.2	-12.5 $\pm$ 5.9	0.24
	maximum hip flexion angle at MSw	30.4 $\pm$ 3.9	28.9 $\pm$ 5.6	0.51
	maximum knee flexion angle at LR	12.1 $\pm$ 5.9	10.1 $\pm$ 4.3	0.41
	maximum knee extension angle at MS	4.2 $\pm$ 2.9	4.9 $\pm$ 2.4	0.58
	maximum knee flexion angle at ISw	55.7 $\pm$ 8.7	57.2 $\pm$ 6.2	0.67
	maximum dorsiflexion angle at TSt	14.6 $\pm$ 3.1	14.7 $\pm$ 2.3	0.97
	maximum plantarflexion angle at PSw	-15.8 $\pm$ 3.6	-15.0 $\pm$ 5.1	0.71
<b>Frontal</b>	maximum pelvic obliquity at LR	4.1 $\pm$ 1.6	4.6 $\pm$ 1.6	0.53
	maximum hip adduction angle at LR	7.6 $\pm$ 2.3	7.6 $\pm$ 3.0	0.97
	maximum hip abduction angle at ISw	-5.9 $\pm$ 2.6	-8.1 $\pm$ 2.5	0.10
	maximum knee adduction angle at MSw	31.2 $\pm$ 9.4	29.1 $\pm$ 8.4	0.62
	maximum knee abduction angle at MSt	0.1 $\pm$ 3.8	0.4 $\pm$ 2.5	0.83
<b>Transverse</b>	maximum internal rotation of pelvic at IC	5.4 $\pm$ 2.6	5.9 $\pm$ 3.8	0.74
	maximum external rotation of pelvic at TSt	-8.1 $\pm$ 2.9	-6.9 $\pm$ 2.3	0.39

Note: IC = initial contact, LR = loading response, MSt = mid-stance, TSt = terminal stance, PSw = pre-swing, ISw = initial swing, MSw = mid-swing, TSw = terminal swing.

Table 3. Ground Reaction Force (GRF) data (mean and SD) for the dancers and non-dancers in three planes of movement.

Plane	Variables	Dancer	Non-dancer	p-value
		Mean $\pm$ SD	Mean $\pm$ SD	
<b>Sagittal</b>	peak anterior force at IC	0.3 $\pm$ 2.4	0.4 $\pm$ 1.6	0.89
	peak posterior force at LR	-14.2 $\pm$ 1.8	-14.3 $\pm$ 3.1	0.96
	peak anterior force at TSt	18.5 $\pm$ 2.1	19.2 $\pm$ 2.5	0.51
<b>Frontal</b>	peak lateral force at IC	-3.2 $\pm$ 1.0	-3.1 $\pm$ 1.6	0.88
	peak medial force at LR	4.7 $\pm$ 1.2	5.2 $\pm$ 1.6	0.41
	peak medial force at MSt	2.7 $\pm$ 0.8	2.9 $\pm$ 1.1	0.64
	peak medial force at TSt	5.5 $\pm$ 1.0	5.6 $\pm$ 1.5	0.84
	peak lateral force at PSw	-1.1 $\pm$ 0.9	-1.1 $\pm$ 1.1	0.96
<b>Transverse</b>	peak vertical force at LR	101.7 $\pm$ 4.3	101.8 $\pm$ 3.5	0.98
	peak vertical force at MSt	84.4 $\pm$ 4.1	86.7 $\pm$ 3.3	0.20
	peak vertical force at TSt	110.8 $\pm$ 5.8	110.4 $\pm$ 4.4	0.89

Note: IC = initial contact, LR = loading response, MSt = mid-stance, TSt = terminal stance, PSw = pre-swing, ISw = initial swing, MSw = mid-swing, TSw = terminal swing.

Khon masked dancers revealed a higher anterior pelvic tilt angle at terminal swing (8.5  $\pm$  4.6) and external rotation angle at terminal stance (-8.1  $\pm$  2.9), hip flexion angle at mid-swing

(30.4  $\pm$  3.9), knee flexion angle at loading response (12.1  $\pm$  5.9), and adduction (valgus) at mid-swing (31.2  $\pm$  9.4) than non-dancers during the normal walking in Table 2.

#### 4. Discussion

This is the first study to determine the gait pattern of Khon masked dancers by kinematic and kinetic variables. Previous studies assessed gait parameters between dancers and non-dancers mostly in ballet dance and showed significant differences in kinematic and kinetic variables [12, 22, 23]. In our study, there was no significant difference between Khon mask dancers and non-dancers. All participants included in the study were healthy adults. Therefore, this study provided information on Khon dance training that does not significantly alter the walking pattern. The Khon dance is delicate and their movement pattern is a little slower than other kinds of dance [16]. This supported our hypothesis that Khon masked performance and training might not heavy when compare to the ballet. However, the comparative study on training effect between dance performance is recommended.

We found ankle plantar flexion at late phase of stance was not very difference between two groups although Khon masked dancer keep ankle eversion during performance and training time. It is important to prevent the risk of slipping that was caused by the reduced push-off phase of the stance leg [2]. Previous ballet studies showed that dancers had an increase in ankle plantar flexion in pre-swing because of dysfunction of the first metatarsophalangeal joint and overloading stress on flexor hallucis longus when compared to the control group as a result of the long training effect of pointing toe position [24, 25]. It has been reported that foot injury is the second prevalence of injury in Thai classical dancers [26]. However, the position of foot during performance in Khon masked dance is different to ballet. The study of foot biomechanics during Khon masked performance and comparative with ballet dance should be considered.

Our data showed that there were no significant differences in knee flexion and hip flexion angles during the gait cycle but the values were higher in the Khon dancer than the non-dancer group. Increased knee flexion in walking is one of the typical dancing position for Khon dance. They always keep a deep square squat position in both training and performance time. There is a

similarity between Khon dance and ballet dance called grand pile position for the posting position in hip external rotation, knee flexion, and ankle eversion [10]. Ballet dancers also greater knee flexion and hip flexion in swing phase so that knee extension is decreased in that phase of walking than non-dancers [22]. This can cause higher concentric activity on the rectus femoris muscle and also increased hip joint flexion during the swing phase and it was related between knee flexion in swing phase and ankle dorsiflexion in the terminal stance [27]. Knee and hip muscle performance in Khon masked dancers is recommended for further study.

The dancer must maintain an upright and erect trunk position and squatting position to be graceful in their performance. This position necessitates a combination of movements like hip flexion, abduction, external rotation, and knee flexion in a closed kinetic chain position attempt to increase the turnout at the hip joint [23]. It can increase in lumbar lordosis which places the hip joint in a position where the capsular ligaments are loosened leading to anterior pelvic tilt [27]. However, our study showed the anterior pelvic tilt was not significant difference. This effect might be related to the duration of training. The experience and duration of training per day of Khon masked dancers might lead to the postural control during walking [17, 28]. Our participants reported lesser than 10 years of experience. The greater of training experience and the information of training duration are recommended for further investigation.

There were no significant changes in GRF for all three directions between Khon dancers compared and non-dancers during walking. Other kinds of dance studies found increased medial shear force in the dancer group [29, 30]. Dancers used more foot eversion than non-dancers that is the reason to cause higher medial shear force [7]. Researchers demonstrated a strong relationship between the change of foot position and the magnitude of medial-lateral shear force [6, 7]. The Khon masked training might be not heavy when compare to ballet or other dances. This might not be effect to the physical or structural changes. However, the greater of training experience is

recommended for further investigation.

## 5. Conclusion

Illustrating the differences in Khon masked dancers' gait and healthy participants is the first study to find how Khon dance training affected daily movements. The results demonstrated that there was no significant difference in lower extremity kinematics and kinetics during normal walking between dancers having long-term intensive Khon training and non-dancers. However, this biomechanical information would be helpful for clinicians and dance educators to use these data in the clinic, to educate Khon dance for safety, and to prevent the risk of injury.

## Study Limitations

The limitations in this study were composed of, first, small number of participants. A larger number of participants is recommended for further investigation. Second the comparative of experience effect of Khon masked dancers on gait pattern is also recommended.

## Acknowledgements

This study has been supported by research grant from the Mahidol University (NDFR 07/2563). The author would like to acknowledge the Faculty of Physical Therapy, participants who involved in this study and Ms. Pakamas Jearudomsup for her contribution to this study.

## Conflict of interest

The authors have no conflict of interest to declare.

## References

- [1] Akhtaruzzaman MD, Shafie AA, Khan MR. Gait analysis: systems, technologies, and importance. *J Mech Med Biol*. 2016; 16(07): 1630003. doi: 10.1142/s0219519416300039
- [2] Baker R. Gait analysis methods in rehabilitation. *J Neuroeng Rehabil*. 2006; 3(1): 4. doi: 10.1186/1743-0003-3-4
- [3] Chutimakul L, Sukonthasab S, Kritpet T, Vannalee C. Effect of modified Khon dance performance on functional fitness in older Thai persons. *J Health Res*. 2018; 32(6): 432-9. doi: 10.1108/jhr-05-2018-0009
- [4] Gallagher NE, Bruce-Brand R, Bennett D, O'Brien S, Beverland DE. No difference in gait kinematics or kinetics between limbs in bilateral total hip replacement patients at long-term follow-up. *Clin Biomech (Bristol, Avon)*. 2019; 67: 166-70. doi: 10.1016/j.clinbiomech.2019.05.007
- [5] Lencioni T, Carpinella I, Rabuffetti M, Marzegan A, Ferrarin M. Human kinematic, kinetic and EMG data during different walking and stair ascending and descending tasks. *Sci Data*. 2019; 6(1): 309. doi: 10.1038/s41597-019-0323-z
- [6] Farzadi M, Sanjari MA, Jalali M, Saedi H, Kamali M, Movahedi Yeganeh M. Ground reaction force complexity in hallux valgus. *Clin Biomech (Bristol, Avon)*. 2021; 81: 105229. doi: 10.1016/j.clinbiomech.2020.105229
- [7] Farzadi M, Sanjari MA, Jalali M, Saedi H, Kamali M, Movahedi Yeganeh M. Foot structural factors and ground reaction force in hallux valgus grades. *Foot (Edinb)*. 2020; 45: 101689. doi: 10.1016/j.foot.2020.101689
- [8] Emery S, Cook J, Ferris AR, Smith P, Mayes S. Hip flexor muscle size in ballet dancers compared to athletes, and relationship to hip pain. *Phys Ther Sport*. 2019; 38: 146-51. doi: 10.1016/j.ptsp.2019.05.003
- [9] Prochazkova M, Tepla L, Svoboda Z, Janura M, Cieslarova M. Analysis of foot load during ballet dancers' gait. *Acta Bioeng Biomech*. 2014; 16(2): 41-5. doi: 10.5277/abb140205
- [10] Vastola R, Coppola S, Sibilio M. Motion analysis technologies for biomechanical gait and postural analysis in ballet. *J Sports Sci*. 2016; 4(4). doi: 10.17265/2332-7839/2016.04.008
- [11] Rowley KM, Shih HS, Traina K, Winder B, Mikkelsen P, Kulig K. Effects of a "toes-off" modified heel raise on muscle coordination in non-dancers, dancers, and dancers with flexor hallucis longus tendinopathy. *Clin Biomech (Bristol, Avon)*. 2021; 83: 105287. doi: 10.1016/j.clinbiomech.2021.105287
- [12] Astone S, Mignone A, Albano D. Comparison of gait kinematics and kinetics between qualified dancers and non-dancers. *J Physic Educ Sport*. 2019; 2019(6): 2289-91. doi: 10.7752/jpes.2019.s6345
- [13] Krasnow D, Wilmerding MV, Stecyk S, Wyon M, Koutedakis Y. Biomechanical research in dance: a literature review. *Med Probl Perform Art*. 2011; 26(1): 3-23. doi: 10.21091/mppa.2011.1002

- [14] Barnes MA, Krasnow D, Tupling SJ, Thomas M. Knee rotation in classical dancer during the grand plie. *Med Probl Perform Art.* 2000; 15: 140-7.
- [15] Fukuchi CA, Fukuchi RK, Duarte M. Effects of walking speed on gait biomechanics in healthy participants: a systematic review and meta-analysis. *Syst Rev.* 2019; 8(1): 153. doi: 10.1186/s13643-019-1063-z
- [16] Chansuwan S. Thai traditional choreography: differences between the male character of Khon and Lakhon dance. *SPAFA Journal.* 2005; 15(2): 45-55.
- [17] Kritiyakiarana W, Jongkamonwiwat N. Comparison of balance performance between Thai classical dancers and non-dancers. *J Dance Med Sci.* 2016; 20(2): 72-8. doi: 10.12678/1089-313X.20.2.72
- [18] Kritiyakiarana W, Jongkamonwiwat N. Greater star excursion balance test performance in Thai Khon masked dancers versus nondancers. *J Dance Med Sci.* 2022; 26(3): 146-54. doi: 10.12678/1089-313X.091522a
- [19] Day H, Koutedakis Y, Wyon MA. Hypermobility and dance: a review. *Int J Sports Med.* 2011; 32(7): 485-9. doi: 10.1055/s-0031-1273690
- [20] Bläsing B, Tenenbaum G, Schack T. The cognitive structure of movements in classical dance. *Psychol Sport Exerc.* 2009; 10(3): 350-60. doi: 10.1016/j.psychsport.2008.10.001
- [21] Lung CW, Chern JS, Hsieh LF, Yang SW. The Differences in gait pattern between dancers and non-dancers. *J Mech.* 2011; 24(4): 451-7. doi: 10.1017/s1727719100002562
- [22] Janura M, Tepla L, Strakova P, Kubonova E, Svoboda Z, Javurek F. Comparison of gait kinematics between professional ballet dancers and non-dancers. *Neuro Endocrinol Lett.* 2018; 39(5): 385-90.
- [23] Teplá L, Procházková M, Svoboda Z, Janura M. Kinematic analysis of the gait in professional ballet dancers. *Acta Gymnica.* 2014; 44(2): 85-91. doi: 10.5507/ag.2014.009
- [24] Cardoso AA, Reis NM, Marinho APR, Vieira MdCS, Boing L, de Azevedo Guimarães AC. Injuries in professional dancers: a systematic review. *Revista Brasileira de Medicina do Esporte.* 2017; 23(6): 504-9. doi: 10.1590/1517-869220172306170788
- [25] Kerrigan DC, Riley PO, Rogan S, Burke DT. Compensatory advantages of toe walking. *Arch Phys Med Rehabil.* 2000; 81(1): 38-44.
- [26] Kritiyakiarana W, Thippawan C, Nattanicha C, Jullumjiak P. Prevalence of musculoskeletal injuries in Thai classical dancers. *Research in Dance Education.* 2022: 1-15. doi: 10.1080/14647893.2022.2115993
- [27] Moita JP, Nunes A, Esteves J, Oliveira R, Xarez L. The relationship between muscular strength and dance injuries: a systematic review. *Med Probl Perform Art.* 2017; 32(1): 40-50. doi: 10.21091/mppa.2017.1002
- [28] Gautier G, Thouvarecq R, Larue J. Influence of experience on postural control: effect of expertise in gymnastics. *J Mot Behav.* 2008; 40(5): 400-8. doi: 10.3200/JMBR.40.5.400-408
- [29] Carter SL, Bryant AR, Hopper LS. An analysis of the foot in turnout using a dance specific 3D multi-segment foot model. *J Foot Ankle Res.* 2019; 12(1): 10. doi: 10.1186/s13047-019-0318-1
- [30] Zhao Y, Liu Z, Zhang X, Yang L, Chen W. Analysis of characteristics in China classic dancers' gait pattern. *Leather and Footwear Journal.* 2018; 18(2): 131-8. doi: 10.24264/lfj.18.2.8

# Impact of Measures on Reducing Cumulative Case Numbers of the First Wave of COVID-19 in Thailand

Kanokkan Wongsawat <sup>a</sup>, Patumrat Sripan <sup>b, \*</sup>, Pimwarat Srikummoon <sup>a, c</sup>,  
 Patrinee Traisathit <sup>a, c, d</sup>, Pallop Siewchaisakul <sup>e</sup>, Linda Aurbibul <sup>b</sup>,  
 Amaraporn Rerkasem <sup>b</sup>, Patcharaphan Sugandhavesa <sup>b</sup>, Salinee Thumronglaohapun <sup>a, c</sup>

<sup>a</sup> Department of Statistics, Faculty of Science, Chiang Mai University, Chiang Mai, Thailand

<sup>b</sup> Research Institute for Health Sciences, Chiang Mai University, Chiang Mai, Thailand

<sup>c</sup> Data Science Research Center, Department of Statistics, Faculty of Science, Chiang Mai University, Chiang Mai, Thailand

<sup>d</sup> Research Center in Bioresources for Agriculture, Industry and Medicine, Chiang Mai University, Chiang Mai, Thailand

<sup>e</sup> Faculty of Public Health, Chiang Mai University, Chiang Mai, Thailand

## Abstract

**Background:** Non-pharmaceutical countermeasures (NPC) and lockdowns were adopted to combat the first wave of Coronavirus disease 2019 (COVID-19) in Thailand. The impacts and timing of when to implement such measures have been rarely demonstrated in Thailand. We aimed to elucidate the impacts of NPC and lockdown for containing COVID-19 under various scenarios in Thailand.

**Method:** The daily information of infected patients was retrieved from the online database of the ministry between 31 January 2020 and 31 July 2020. The Autoregressive Integrated Moving Average (ARIMA) with intervention was used to analyze the effect of these public health measures. ARIMA (2, 1, 2) and ARMA (2, 2) was built and used to forecast the daily case numbers under different scenario simulations using a dynamic method, which showed the similarity between actual and predicted values of Covid-19 cases with RMSE of 19.49.

**Results:** This model was built and used to forecast the daily case numbers under different scenario simulations using a dynamic method. Our study showed high adherence rates of the population to public health guidelines. The public health measure and lockdown was significant effectively reducing the daily COVID-19 infected cases by 32 cases. Based on the simulation, the sooner of enforcing the measures, the lower the cumulative COVID-19 cases.

**Conclusion:** The public health measure and lockdown significantly reduced the incident COVID-19 within the country. We suggest that the efforts with use of these non-pharmaceutical prevention measures still needed until effective levels of vaccination are achieved nationally.

**Keywords:** COVID-19, first wave, public health measures, lockdown, ARIMA

## 1. Introduction

The pandemic of coronavirus disease 2019 (COVID-19) is an infectious disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [1]. The World Health Organization (WHO) declared this as a global pandemic on 11 March 2020 [2]. As of May 2021, there have been approximately

166,860,081 confirmed cases of SARS-CoV-2 infection and 3,459,996 deaths from COVID-19 [3].

The initial outbreak of COVID-19 was in Wuhan China [4, 5]. COVID-19 cases have subsequently spread rapidly worldwide due to many factors including international travel [6]. Thailand was the most at risk country of

\* Corresponding author.

E-mail address: pspatumrat3@gmail.com; patumrat.sripan@cmu.ac.th (Patumrat Sripan)

importation after the implementation of the Wuhan travel ban from 23 January 2020 to 1 March 2020 [7]. The Department of Disease Control (DDC), Ministry of Public Health (MOPH) in Thailand scaled up the Emergency Operations Center (EOC) to closely monitor the ongoing situation both at the national and international levels [8]. Thailand was the first country outside of China with a confirmed case of COVID-19 [9].

The first local transmission in Thailand was detected on 31 January 2020 [10, 11]. The number of local confirmed cases had increased sharply in mid-March in Thailand, for there were two major super spreading venues, an entertainment venue and a Thai boxing stadium in Bangkok [12]. There was no COVID vaccines available at that time-period, non-pharmaceutical countermeasures (NPC) were the mainstay of controlling disease spread. This consisted of case isolation, contact tracing and quarantine, encouragement of physical distancing and proper hand hygiene, and city lockdown [1]. Furthermore, the Ministry of Public Health managed village health volunteers to look for potential cases of COVID-19, focusing on people suspected to be at risk of infection [13]. The lockdown in Thailand was not a complete lockdown as in Wuhan, China. In Thailand. The Thai lockdown restriction policy consisted of banning all international flights, closing a range of retail business, people were asked to stay at their home, and to limit all social contacts [12, 14, 15]. The public health measures were officially announced by Department of Disease Control on April 6, 2020, and consisted of self-protective behaviors (including proper hand hygiene, wearing masks and eating cooked food) and social behaviors (including physical distancing and avoidance of unnecessary travel). In addition, the Thai government requested every provincial governor to set up volunteer teams for detecting and surveillance for COVID-19 at the district and village level, for some people returning to their home, due to suspension of many jobs in Bangkok [16].

Although able to help reduce disease transmission many of these measures, especially

travel restrictions, carry significant economic costs, particularly for Thailand [17, 18]. According to a recent estimate by the World Travel and Tourism Council (WTTC) [19], the Thai tourism sector is an essential segment of the economy, accounting for 19.7 per cent of GDP. The IMF predicts that Thailand's 2020 GDP dropped by 6.7 per cent [12] as a result of a combination of factors, primarily Thailand's economic condition before COVID-19 and the heavy reliance of the Thai economy on tourism.

As a result, understanding the timing and impacts of interventions (public health measures) are essential for policy makers to make decision on implementation of control measures. However, few studies have been investigated the impact of the NPC in Thailand [6, 12]. One statistical method, an Autoregressive Integrated Moving Average (ARIMA) model, has been widely used to evaluate impacts of an intervention on a population [20]. This statistical method can simulate cumulative cases by different time of NPC implementation [21]. We applied the ARIMA with intervention analysis to estimate the overall impact of public health measures, including lockdown on reducing the cumulative cases during the first wave of the COVID-19 outbreak in Thailand. This study aimed to quantify and evaluate the impact of public health measures for containing COVID-19 in different timing of implementation of these measures in Thailand.

## 2. Methods

### 2.1. Data Collection

We collected information of patients diagnosed with infection with SARS-CoV-2 in Thailand, including date, sex, age and region of diagnosis. This data was retrieved from the online database of the Department of Disease Control, Ministry of Public Health [22] which was open for public and logged all local transmitted patients with laboratory-confirmed COVID-19 from 31 January 2020 to 31 July 2020. Local transmitted patients refer to those contacted with other COVID-19 patients, contacted with passenger when arrived Thailand, got infection in community, had high-risk occupations, were

detected via proactive case-finding, tested for COVID-19 before performing medical procedures, or other contact routes within country. All cases of COVID-19 entered into the Department of Disease Control database had been diagnosed using RT-PCT of nasopharyngeal and throat swabs or from sputum of patients with lower respiratory tract infections (such as pneumonia and acute respiratory distress syndrome (ARDS)).

## 2.2. Determination of the public health measures

After the Department of Disease Control and Ministry of Public Health have scaled up the Emergency Operations Center to level 2 to closely monitor the ongoing situation both at the national and international levels, Thailand government advised people to keep washing hands, wearing masks and avoiding contact with patients who have a respiratory disease since then, and until present [8]. The government officially announced national lockdown on 26 March 2020. The lockdown mandate was eased at the beginning of June and ended on 31 July 2020. In phase 1 (26 March 2020 - 30 April 2020), the government closed risk places such as boxing stadiums and night clubs, prohibited foreigners to come into the country except for Thai people, and prohibited news agencies to present the news which distorted intently information. In addition, the government requested for cooperation the adherence to measures; prohibition of the residence during 10 pm - 4 am, prohibition of gathering in public places included educational institutions, prohibition of entering in other risk areas such as markets competitions or department stores where lead to local transmission, and prohibition of traveling across to other provinces.

In phase 2 (1 May 2020 - 31 May 2020), educational institutions were opened. Economic and healthy activities such as department stores restaurants or health parks could open until 8 pm. In addition, people still adhered to prohibition of the residence during 11 pm - 4 am.

In phase 3 (1 June 2020 - 30 June 2020), economic and healthy activities could open until 9 pm. Moreover, people could travel across other provinces but stayed in the residence from 11 pm - 3 am.

In phase 4 (1 July 2020 - 31 July 2020), all public places were opened. People must adhere to the public health measures when people came into such places such as entry and exit registration in department stores with Thai Chana application or registration form [23].

The Department of Disease Control requested for cooperation the adherence to 5 public health measures for Thai people, which were comprised of 1) avoiding touching of the face, mouth, or nose, 2) maintaining physical distancing of 1-2 meters, 3) eating hot food using personal utensils, 4) properly washing hands with soap or alcohol hand sanitizer, and 5) wearing face masks in public [24]. Fig. 1 shows the adherence to public health measures from April 2020 to June 2020 in Thailand [25, 26].

## 2.3. Intervention timing

Determination of the intervention and the time point of the intervention is essential for ARIMA with intervention analysis. Since all 5 public health measures were fully implemented on 6 April 2020 which were the intervention in our study. Therefore, the intervention point was the implementation of public health measures which began on 6 April 2020, in which the national lockdown was implemented on 26 March 2020. In our study, we divided data into 2 periods: pre-public health measures (from 31 January 2020 to 5 April 2020) and post-public health measures (from 6 April 2020 to 31 July 2020).

## 2.4. Statistical Analysis

Characteristics of patients infected during the two time periods before and after the intervention were presented as frequency and percentage for gender and region of diagnosis and as a median with range for age. ARIMA model explained a given time series based on its own past values, and a general form was an ARIMA (p, d, q), where p is the number of autoregressive (AR) terms, q is the number of moving average (MA) terms in the prediction equation, and d is the order of differences needed for stationarity [27]. The ARIMA with intervention is the time series model based on Box & Jenkins' method that integrates with an intervention function was used

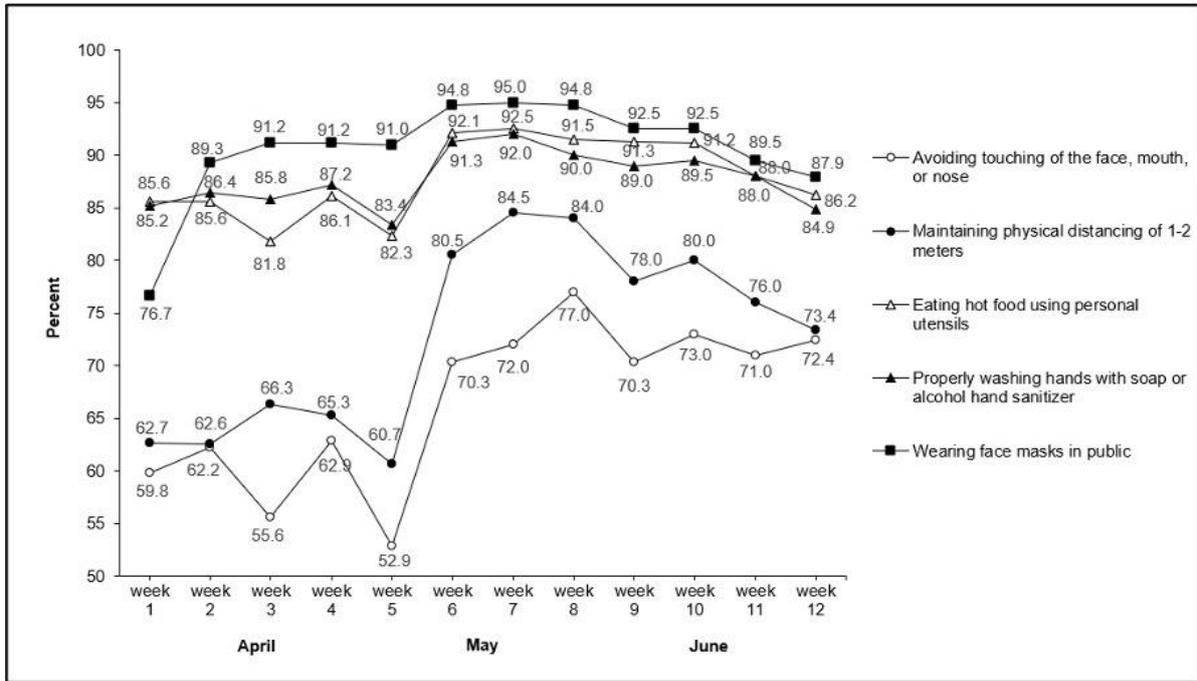


Fig. 1. Adherence to public health guidelines in Thailand, April 2020 to June 2020.

Table 1. Characteristics of COVID-19 patients in Thailand between 31 January 2020 and 31 July 2020

Characteristics	Before implementation of public health measure	After implementation of public health measure	Total N=2233
<b>Sex</b>			
Male	833 (52.0%)	271 (44.0%)	1104 (49.0%)
Female	783 (48.0%)	346 (56.0%)	1129 (51.0%)
<b>Age (years)</b>			
Age range	0.1 - 84	1 - 97	0.1 - 97
Interquartile Range (IQR)	36 (27 - 48)	37 (27 - 51)	36 (27 - 49)
<b>Region*</b>			
Central	1162 (74.0%)	318 (52.0%)	1480 (68.0%)
Southern	190 (12.0%)	249 (40.0%)	439 (20.0%)
Eastern	75 (5.0%)	26 (4.0%)	101 (5.0%)
Northeastern	86 (5.0%)	12 (2.0%)	98 (4.0%)
Northern	66 (4.0%)	9 (2.0%)	75 (3.0%)

\* Missing value = 40

to analyze the effect of an intervention on event that changes by time of implementing [21]. This model was built and used to predict the daily number of COVID-19 cases. The procedures of this analysis were 1) verification of stationary data using the Augmented Dickey Fuller test, 2) determination of ARIMA with intervention model for analyzing the effect of an intervention

on change in number of cases, and 3) validation of the model fit. The intervention variable was an independent variable ( $X$ ) that affects the dependent variable ( $Y$ ). The general form of ARIMA with intervention at time  $t$  was written as  $y_t = \beta_0 + \beta_1 intervention_t + \rho_1(y_{t-1} - \beta_0 - \beta_1 intervention_{t-1}) + \theta_1 \epsilon_{t-1} + \epsilon_t$  on ARIMA (1,1,1), where  $y_t$  was the observation in the time series at time  $t$ ,  $\beta_0$  was

constant,  $\beta_1$  was the coefficient that showed the effect of intervention,  $\rho_1$  was first parameter of Autoregressive (AR) (1), and  $\theta_1$  was first moving average parameter of Moving Average (MA) (1). Intervention was a dummy variable, where 0 was the pre-intervention period and 1 was the post-intervention period and  $\varepsilon_t$  was the error at time  $t$ . The Portmanteau test or Box and Pierce (Q-statistic) test was used for autocorrelation test. The final model without autocorrelation was used to forecast the daily number of cases of COVID-19 at time  $t$ , based on the previous observation and continuously until the end of the study period. Accuracy of the forecast model was verified using root mean square error (RMSE), which is a measurement of the difference between actual values and predicted values from a squared model. The model is considered to accurately predict values close to the actual value when the RMSE value is small [28].

### 2.5. Scenario simulation of various initiation times of public health measures

The ARIMA model with intervention was developed and employed to forecast the number of daily cases in different scenario simulations using dynamic methods. This forecast had the predicted value at time  $t$  that was based on the previous observation, but the predicted value at time  $t+1$  based on the predicted value at time  $t$ , the predicted value at time  $t+2$  based on the predicted value at time  $t+1$  and continuously until the end of the study period [29]. The cumulative numbers of cases counting from the date that the first case occurred until the number of cases

declined to zero were also predicted using the different time points of measure implementation.

### 3. Results

Between 31 January 2020 and 31 July 2020, there were 2233 domestic COVID-19 cases in Thailand. Most of them were females, with a median age of 36 years (IQR=27 to 48 years), and 74.0 per cent were found in the central region of Thailand (Table 1).

Fig. 1 depicts the adherence to public health measures from April 2020 to June 2020 in Thailand, measures which consisted of 1) avoiding touching of the face, mouth, or nose, 2) maintaining physical distancing of 1 - 2 meters, 3) eating hot (food) using personal utensils, 4) properly washing hands with soap or alcohol hand sanitizer, and 5) wearing face masks in public. Measures with the highest adherence rates (over 80.0 per cent after the 1<sup>st</sup> week) were wearing face masks in public, eating hot (food) using personal utensils, and properly washing hands with soap or hand sanitizer. Adherence to physical distancing guidelines and avoidance of touching the face, mouth, or nose were lower but increased sharply at the 6<sup>th</sup> week, from 60.7 per cent to 80.5 per cent and 52.9 per cent to 70.3 per cent, respectively.

After development and adjustment of the ARIMA with intervention model, we found that the public health measure and lockdown all together was linked to a reduction in the number of incident COVID-19 infections by 32 cases/day (Table 2). After adjusting the data with  $\Delta y = y_t - y_{t-1}$ , the ARMA with intervention model

Table 2. Parameter estimates of ARIMA (2,1,2) and ARMA (2,2) with intervention model

Parameters	ARIMA (2,1,2) with intervention			ARMA (2,2) with intervention		
	Estimates	SE	p-value	Estimates	SE	p-value
$\beta_0$	0.1716	0.9494	0.857	1.1107	1.1363	0.328
$\beta_1$	-31.8452	10.0444	0.002	-1.7334	1.9888	0.383
$\rho_1$	-0.3679	0.0685	<0.001	-0.3949	0.0747	<0.001
$\rho_2$	-0.7967	0.0785	<0.001	-0.776	0.0947	<0.001
$\theta_1$	0.2746	0.0856	0.001	0.313	0.0930	0.001
$\theta_2$	0.5575	0.0982	<0.001	0.5222	0.1181	<0.001

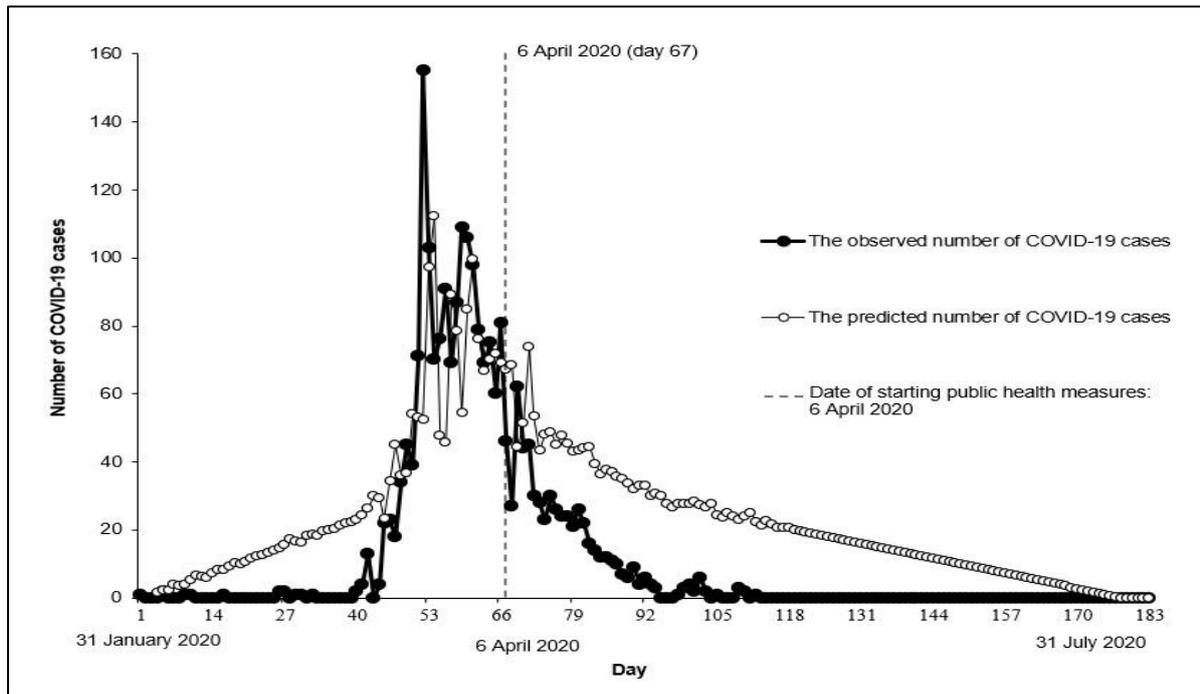


Fig. 2. The observed number (thick line) and the predicted number of COVID-19 cases (thin line) using a dynamic forecasting method.

Table 3. The cumulative number of COVID-19 cases by different time point of implementing public health measures.

Day of an implementation of public health measure after first local case	Cumulative case
30	820
37	1270
44	1725
51	2265
58	3054
65	4188
72	5757

was used with the dynamic method to simulate different COVID-19 scenarios based on variations of timing of preventive measures implementation in Thailand. The observed and predicted number of COVID-19 cases are plotted in Fig. 2. The curves show that the predicted values were fairly similar to the observed values, with a RMSE of 19.49.

Table 3 shows the simulated number of daily COVID-19 cases between January 2020 and July 2020, based on different timings of initiation of preventive measures. In the real situation, when

these measures were initiated on 6 April 2020, the cumulative number of COVID-19 cases was 2233. The simulated cumulative number of the cases at the date of implementing (6 April 2020) was 4379 cases. We observed that the sooner of enforcing the measures, the lower the cumulative COVID-19 cases. Our simulation predicted that the number of the cumulative cases would have been 820, 1270, 1725, 2265, 3054, 4188 and 5757 if initiation of prevention measures were 30 days (1 month), 37 days, 44 days, 51 days, 58 days (2 months) and 72 days (one week following the

actual implementation of measures) after the first locally acquired case was found, respectively.

#### 4. Discussion

The public health measures and lockdown, which officially started on 6 April 2020, had a significant impact on reducing the daily incident numbers of COVID-19 in Thailand by an estimated 32 cases/day. This result is consistent with the observed monthly COVID-19 case reports in March (1240 cases) April (943 cases) and May (38 cases). The previous studies showed the notion that the public health measures and lockdown were effective in preventing the transmission of the disease within the country and also infected cases from outside [6, 12]. The decreasing trends of reproduction number at time  $t$  ( $R_t$ ) plots, showing the effective of the interventions included nationwide curfew and banned all international flights in preventing the transmission of the disease [12]. While another study also reported this effect using different model [6]. Regarding the infection within the country, our finding was in consistent results with these studies.

The level of public participation in the public health measures in particular wearing mask may pay an important role in this decrease. Several studies have attempted to quantify the benefit of mask wearing in preventing the spread of COVID-19 [30-32]. For example, the reductions have been reported in case contact investigations when contacts were masked [31] and in household clusters in which household members were masked [32]. In the US population, estimated overall decline in new diagnoses of 0.9 per cent at initial daily and grew to 2.0 per cent at 21 days following mandatory mask wearing in public [33]. In Thailand, the participation in the public health measures was relatively high (Fig. 1). The Thai population had a good compliance (80.0 per cent after 1<sup>st</sup> week) in wearing face masks in public, eating hot (food) and using personal utensils, and regularly washing hands with soap or hand sanitizer. While compliance rates for other measures like physical distancing and avoiding touching of the face, mouth or nose were lower, these behaviors also increased after the

6<sup>th</sup> week, from 60.7 per cent to 80.5 per cent and 52.9 per cent to 70.3 per cent, respectively.

Beside high percent of the public health measures compliance authorities used some measures that forced people to cooperate as well. For example, the curfew measures were implemented under the Emergency Decree announcement and listing COVID-19 in the Communicable Disease Act. The police set check-points to enforce the curfew. The approach to handling the situation and the strength of the healthcare personnel were also a part of this success [12]. The government implemented the policies to keep recovered patients at special places for two weeks after starting symptom. Moreover, Thailand has the network of health volunteers in the village to track and isolate citizens after massive migration from Bangkok during national public holidays.

The lockdown measures included the closure of schools (including universities), the full lockdown, and the shutdown of non-essential economic activities implemented in Italy produced a reducing trend on COVID-19 cases [34]. In mainland China, the travel restriction of Wuhan delayed the overall progression of the pandemic by only 3 to 5 days but had a more marked effect on the international scale [7]. Although the effect of lockdowns appears to be positive, it is difficult to quantify given different setting such as initial time, duration, and combination with other public health measures. In Thailand, the lockdown had a great impact on reducing individual mobility, including cross-border movement [12]. Using massive travel restrictions or lockdown approaches to handle the COVID-19 outbreak, initial time and duration of lockdown need to be considered for a good balance to achieved reducing COVID-19 cases while avoiding to much economic damage.

Based on these simulations, we found that the sooner measures are implemented following discovery of the first local transmission of COVID-19, the lower the cumulative number of forecast COVID-19 cases in the first wave of the epidemic in Thailand. If implemented at 30 days, 820 cases were projected and if implementation began at 58 days, 3054 cases were projected

(Table 3). Using ARIMA model, we varied the time point to start the measures and lockdown based on certain date after the occurrence of the first local transmission case, 1 months, 2 months in which the forecasted daily cases depended on the actual number of cases found a day before implementing of intervention and the effect of intervention. However, the more appropriate indicators of action needed for example the increasing trend of  $R_t$  maybe need to address [35]. A study found that timing the start of a complete lockdown 30 days or more prior to the epidemic peak could have little appreciable effect on reducing either the total incidence rate or the peak of hospitalizations [36]. However, obtaining a realistic timing of the peak and the actual incidence seem unattainable given the uncertainties involving the COVID-19 pandemic.

The ARIMA with intervention analysis was used in this present study to analyze the effects of Thailand's public health measures and lockdown, and to predict daily cases of incident COVID-19. The predicted cumulative cases from our model over-estimated the observed cumulative case from 31 January 2020 to 31 July 2020 (4379 cases versus 2333 cases). Several mathematical models have been employed to forecast the daily infected and cumulative cases. Triukose et al. demonstrated the effect of the prevention strategies on decreasing trends of  $R_t$ , while another study [6] found that the moving averages gave the better results for short term prediction than the Susceptible Exposed Infectious and Recovered (SEIR) dynamic approach, which is more suitable for longer period prediction. Our study predicted the daily case using a dynamic forecasting method for modeling. The model in our study provided a higher RMSE than the previous Thai study (19.49 vs 12.8 for SEIR model and 0.21 for two-day moving average model) [6]. However, the model used in our study allowed us to simulate numbers of daily and cumulative cases based on different initiation times of preventive measures.

Our study proposed a model that can help provide daily expected incident and cumulative COVID-19 cases. The model may aid policy makers to take action in the future when the new

outbreak may occur. However, it needs to be applied under similar condition to the early stage of COVID-19 pandemic, widely spreading with only availability of NPC measures. Our model has the assumption that the effect of intervention is the same with any starting point. Moreover, the increasing of cases may be related to the active case finding that could interrupt this assumption. Therefore, this model is under the condition that during the first wave of COVID-19 in Thailand, the active finding method was conducted in specific area in the southern Thailand and only 55 cases (2.5 per cent) were detected by this method, 41 cases in April 2020 and 14 cases in May 2020.

The limitation of our study is that our results is applicable only for managing COVID-19 situation or other newly emerging diseases during the early period when people have no experience and vaccine for COVID-19. Moreover, the model could not address some confounding factors associated with the incident of infection in this study.

During the first wave, most of the infected cases occurred in the central, mainly in Bangkok and the south, mainly in Phuket and some in the tourists' target areas. After the first wave, the situation was under control until a worker at a seafood market in Samut Sakhon province tested positive for COVID-19 in December 2020. This was a beginning of second widespread in specific area Thailand. Most of them were migrant workers from neighboring countries. More cases were reported in other provinces, including Bangkok. Then, the third wave of the outbreak began in early April 2021 and is thought to have originated in Bangkok's Thonglor area nightclubs. Clusters of cases have also broken out in other areas in Bangkok for example Klong Toey and spread further to other provinces. Thailand's vaccination program has been launched and divided into three phases, with priority given to healthcare personnel, the elderly and the seriously ill, and then the general population. The vaccines have been administered by the national vaccine committee and the Public Health Ministry has closely monitored and assessed the procedures. The first group of Thai people received the vaccine around February

2021; however, as of the time of writing the vaccination coverage is still low.

Since the tourism industry is one of Thailand's main economic sectors, accounting for 6-7% of its GDP, the challenges in the future for Thailand for COVID-19 management is the cross border movement. When the progressive relaxation of restrictions and control measures, international tourist arrivals increased. The routine data collection under epidemiological conditions for the potential monitoring system can help informing future public health decisions.

### Acknowledgements

We would like to thank the researchers at the Research Institute for Health Sciences, Chiang Mai University for providing insight suggestion to this study. We also would like to thank Dr. Voravit Suwanvanichkij for a proofreading. This research work was supported by Chiang Mai University.

### Recommendations

The public health measures and lockdown policy were significant effectively reducing the COVID-19 infection within the country. We suggest that the efforts with use of these non-pharmaceutical prevention measures still needed until effective levels of vaccination are achieved nationally.

### Funding

No financial support was provided relevant to this article.

### Declaration of Conflicting Interests

The authors declare that they have no competing interests.

### Ethical approval

The study was approved by the institutional review board at the Research Institute for Health Sciences, Chiang Mai University (REC no. 5/2021).

### Data Availability Statement

The datasets used and analyzed during the current study are available from the corresponding

author on reasonable request.

### Author's contributions

KW contributed to the conception and design, data acquisition, performed the statistical analysis, interpreted results and drafted the manuscript.

PS contributed to the conception and design, interpreted results and drafted the manuscript.

PSR, PT and PSW contributed interpretation of data and drafted the manuscript.

LA, AR, PSG and ST revised the manuscript.

All authors read and approved the final manuscript.

### References

- [1] Ferretti L, Wymant C, Kendall M, Zhao L, Nurtay A, Abeler-Dörner L, et al. Quantifying SARS-CoV-2 transmission suggests epidemic control with digital contact tracing. *Science*. 2020; 368(6491): eabb6936. doi: 10.1126/science.abb6936
- [2] World Health Organization [WHO]. WHO director-general's opening remarks at the media briefing on COVID-19 – 11 March 2020. [cited 2021 Jun 2]. Available from: <https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020>
- [3] World Health Organization [WHO]. WHO coronavirus (COVID-19) dashboard. [cited 2021 Jun 2]. Available from: <https://covid19.who.int>.
- [4] Zhu N, Zhang D, Wang W, Li X, Yang B, Song J, et al. A novel coronavirus from patients with pneumonia in China, 2019. *N Engl J Med*. 2020; 382(8): 727-33. doi: 10.1056/NEJMoa2001017
- [5] Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet*. 2020; 395(10223): 497-506. doi: 10.1016/S0140-6736(20)30183-5
- [6] Tantrakarnapa K, Bhopdhornangkul B. Challenging the spread of COVID-19 in Thailand. *One Health*. 2020; 11: 100173. doi: 10.1016/j.onehlt.2020.100173
- [7] Chinazzi M, Davis JT, Ajelli M, Gioannini C, Litvinova M, Merler S, et al. The effect of travel restrictions on the spread of the 2019 novel coronavirus (COVID-19) outbreak. *Science*. 2020; 368(6489): 395-400. doi: 10.1126/science.aba9757
- [8] Department of Disease Control. Daily COVID-19

- situation: report on January 14, 2020 no.11. [cited 2022 Nov 17]. Available from: [https://ddc.moph.go.th/viralpneumonia/eng/situation\\_mor e.php](https://ddc.moph.go.th/viralpneumonia/eng/situation_mor e.php)
- [9] World Health Organization [WHO]. WHO timeline-COVID-19. [cited 2020 Apr 27]. Available from: <https://www.who.int/news-room/detail/27-04-2020-who-timeline---covid-19>.
- [10] Pongpirul WA, Pongpirul K, Ratnarathon AC, Prasithsirikul W. Journey of a Thai taxi driver and novel coronavirus. *N Engl J Med.* 2020; 382(11): 1067-8. doi: 10.1056/NEJMc2001621
- [11] Thepgumpanat, P. Thailand confirms first human-to-human coronavirus transmission. [cited 2020 Jan 31]. Available from: <https://www.reuters.com/article/us-china-health-thailand-idINKBN1ZU10Z>.
- [12] Triukose S, Nitinawarat S, Satian P, Somboonsawatdee A, Chotikarn P, Thammasanya T, et al. Effects of public health interventions on the epidemiological spread during the first wave of the COVID-19 outbreak in Thailand. *PLoS One.* 2021; 16(2): e0246274. doi: 10.1371/journal.pone.0246274
- [13] World Health Organization [WHO]. Thailand's 1 million village health volunteers - "unsung heroes" - are helping guard communities nationwide from COVID-19. [cited 2022 Nov 17]. Available from: <https://www.who.int/thailand/news/feature-stories/detail/thailands-1-million-village-health-volunteers-unsung-heroes-are-helping-guard-communities-nationwide-from-covid-19>.
- [14] Dechsupa S, Assawakosri S, Phakham S, Honsawek S. Positive impact of lockdown on COVID-19 outbreak in Thailand. *Travel Med Infect Dis.* 2020; 36: 101802. doi: 10.1016/j.tmaid.2020.101802
- [15] Department of Disease Control. Corona virus disease (COVID-19). [cited 2020 Jan 24]. Available from: <https://ddc.moph.go.th/viralpneumonia/eng/situation.php>.
- [16] World Health Organization [WHO]. Situation reports (archive). [cited 2020 Feb 10]. Available from: [https://production-cms.who.int/thailand/emergencies/novel-coronavirus-2019/situation-reports-\(archive\)](https://production-cms.who.int/thailand/emergencies/novel-coronavirus-2019/situation-reports-(archive)).
- [17] Ariyapruchya K, Nair A, Yang J, Moroz HE. The Thai economy: COVID-19, poverty, and social protection. [cited 2020 Apr 28]. Available from: <https://blogs.worldbank.org/eastasiapacific/thai-economy-covid-19-poverty-and-social-protection>.
- [18] Nicola M, Alsafi Z, Sohrabi C, Kerwan A, Al-Jabir A, Iosifidis C, et al. The socio-economic implications of the coronavirus pandemic (COVID-19): A review. *Int J Surg.* 2020; 78: 185-93. doi: 10.1016/j.ijssu.2020.04.018
- [19] World Travel & Tourism Council. Economic impact reports. [cited 2020 Feb 10]. Available from: <https://wtcc.org/Research/Economic-Impact>.
- [20] Schaffer AL, Dobbins TA, Pearson SA. Interrupted time series analysis using autoregressive integrated moving average (ARIMA) models: a guide for evaluating large-scale health interventions. *BMC Med Res Methodol.* 2021; 21(1): 58. doi: 10.1186/s12874-021-01235-8
- [21] Jarrett JE, Kyper E. ARIMA modeling with intervention to forecast and analyze chinese stock prices. *Int J Eng Bus Manag.* 2011; 3: 53-8. doi: 10.5772/50938
- [22] Department of Disease Control. Daily COVID-19 report. [cited 2020 Jan 24]. Available from: <https://data.go.th/dataset/covid-19-daily>.
- [23] Thailand Institute of Occupational Safety and Health [T-OSH]. The adherence to measures for Thai people in COVID-19 situation. [cited 2020 Jan 24]. Available from: <https://www.tosh.or.th/covid-19/index.php/announce?start=20>.
- [24] Department of Disease Control. Daily COVID-19 situation: report on April 6, 2020 no. 94. [cited 2020 Jan 24]. Available from: <https://ddc.moph.go.th/viralpneumonia/eng/situation.php>.
- [25] International Health Policy Program [IHHP]. Report of surveying of COVID-19 epidemic prevention during measures weakness. [cited 2020 Apr 13]. Available from: <http://ihpp.thaigov.net/%E0%B8%A3%E0%B8%B2%E0%B8%A2%E0%B8%87%E0%B8%B2%E0%B8%99%E0%B8%9C%E0%B8%A5%E0%B8%81%E0%B8%B2%E0%B8%A3%E0%B8%AA%E0%B8%B3%E0%B8%A3%E0%B8%A7%E0%B8%88%E0%B8%81%E0%B8%B2%E0%B8%A3%E0%B8%9B%E0%B8%8F%E0%B8%B4-3/>.
- [26] Royal Thai Government. Survey results of Thai people are confident that the government will cope with COVID-19, the overview of Thai people slack in self-defense behavior. [cited 2020 Jul 10]. Available from: <https://www.thaigov.go.th/news/contents/details/33276>.
- [27] Sun J. Forecasting COVID-19 pandemic in Alberta, Canada using modified ARIMA

- models. *Comput Methods Programs Biomed Update*. 2021; 1: 100029. doi: 10.1016/j.cmpbup.2021.100029
- [28] Saiuparad S. The development of predictability measurement method for winter monsoon forecasts in Thailand. *Applied Mechanics and Materials*. 2017; 866: 160-3.
- [29] Harvey AC. *Forecasting, structural time series models and the Kalman filter*. Cambridge: Cambridge University Press; 1990.
- [30] Brooks JT, Butler JC. Effectiveness of mask wearing to control community spread of SARS-CoV-2. *JAMA*. 2021; 325(10): 998-9. doi: 10.1001/jama.2021.1505
- [31] Doung-Ngern P, Suphanchaimat R, Panjangampatthana A, Janekrongtham C, Ruampoom D, Daochaeng N, et al. Case-control study of use of personal protective measures and risk for SARS-CoV 2 infection, Thailand. *Emerg Infect Dis*. 2020; 26(11): 2607-16. doi: 10.3201/eid2611.203003
- [32] Wang Y, Tian H, Zhang L, Zhang M, Guo D, Wu W, et al. Reduction of secondary transmission of SARS-CoV-2 in households by face mask use, disinfection and social distancing: a cohort study in Beijing, China. *BMJ Glob Health*. 2020; 5(5): e002794. doi: 10.1136/bmjgh-2020-002794
- [33] Lyu W, Wehby GL. Community use of face masks and COVID-19: evidence from a natural experiment of state mandates in the US. *Health Aff (Millwood)*. 2020; 39(8): 1419-25. doi: 10.1377/hlthaff.2020.00818
- [34] Bonacini L, Gallo G, Patriarca F. Identifying policy challenges of COVID-19 in hardly reliable data and judging the success of lockdown measures. *J Popul Econ*. 2021; 34(1): 275-301. doi: 10.1007/s00148-020-00799-x
- [35] Nishiura H, Chowell G. The effective reproduction number as a prelude to statistical estimation of time-dependent epidemic trends. In: Chowell G, Hyman JM, Bettencourt LMA, Castillo-Chavez C, editors. *Mathematical and statistical estimation approaches in epidemiology*. Dordrecht: Springer; 2009. p. 103-21.
- [36] Oraby T, Tyshenko MG, Maldonado JC, Vatcheva K, Elsaadany S, Alali WQ, et al. Modeling the effect of lockdown timing as a COVID-19 control measure in countries with differing social contacts. *Sci Rep*. 2021; 11(1): 3354. doi: 10.1038/s41598-021-82873-2

# Factors Associated with Complementary Feeding Practices among Mother of Aged 6 to 23 Months Old Children in Cikarang Timur, Indonesia

Ghina Nur Afra, Wandee Sirichokchatchawan \*

College of Public Health Sciences, Chulalongkorn University, Bangkok, Thailand

## Abstract

**Background:** Complementary feeding (CF) practices should be optimized in 6-23 months old to achieve optimal growth and healthy development. However, there are still many young children with malnutrition in Indonesia. and limited information on complementary feeding practices especially in Cikarang Timur. This study aimed to examine the CF practices based on WHO Indicators for IYCF, and its associated factors among mothers of children aged 6 to 23 months old in Cikarang Timur, Indonesia.

**Methods:** For this cross-sectional study, 325 mothers of children aged 6 to 23 months old were selected by simple random sampling from the primary healthcare record. Face-to-face interview was conducted using a structured questionnaire about sample characteristics and four indicators of CF practice including Introduction of solid, semi-solid or soft food (ISSSF), Minimum Dietary Diversity (MDD), Minimum Meal Frequency (MMF), and Minimum Acceptable Diet (MAD). Chi-square test and multiple logistic regression were performed to find associated factors.

**Results:** Result shows that only religion was associated with MMF. While educational level, ethnicity, religion, and occupational status were found to be associated with MDD. For MAD, the significant association were found among children's birth weight, educational level, ethnicity, and religion. Further analyses with multiple logistic regression found that Muslim mothers were 3.01 odds of practicing the MMF (AOR 3.01, 95% CI: 1.13-7.98). For MDD indicators. the result show that mother with other ethnicity than Sundanese and employed mother were 2.74 odds and 5.59 odds respectively practicing dietary diversity to their child (AOR 2.74, 95% CI: 1.49-5.04; AOR 5.59, 95% CI 1.20-25.94). Similar results were observed for practicing MAD, mother with other ethnicity than Sundanese were 3.03 odd of practicing MAD (AOR 3.03, 95% CI: 1.63-5.64). and had secondary education and above were 1.69 odds of practicing MAD.

**Conclusions:** These findings shows that a positive association between mother's education level and MAD practicing. Strengthening national policies to educate women at least to the secondary level might be a cost-effective intervention for improving IYCF practices.

**Keywords:** Associated factors, Complimentary feeding practices, Indonesia, Young children

## 1. Introduction

Age of 6-23 months is the longest period from first 1000 days of life. It is a critical period for optimal growth and development of a child. Complementary feeding (CF) practices directly affect to children's health, development, and nutritional status. Therefore, appropriate complementary feeding (CF) practices are needed

in an effort to prevent malnutrition such as wasting, underweight and stunting [1].

The World Health Organization (WHO) and UNICEF provide guiding principles for complementary feeding practices aged 6-23 months old for breastfed and non-breastfed children in order to provide global guidance to support growth, health, and behavioral

\* Corresponding author.

E-mail address: wandee.s@chula.ac.th (Wandee Sirichokchatchawan)

development in infants and young children (IYC) under the age of two (2). In these guidelines, the introduction of solid, semi-solid or soft food (ISSSF), minimum dietary diversity (MDD), minimum meal frequency (MMF), and minimum acceptable diet (MAD) are core indicators of the nine indicators recommended by WHO in assessing complementary feeding practice throughout the world [2].

However, in global situation, two-thirds of child fatalities are related to improper and suboptimal feeding practices during the first year of life [3]. In developing countries, improper feeding practices still become a major issue. According to the WHO less than one-fourth of children aged 6 to 23 months old that meet the minimum acceptable diet (MAD), dietary diversity, and meal frequency standards [4].

Based on the Indonesia Demographic and Health Surveys (IDHS) between 2007 and 2017, children who consumed a diversified diet tended to stagnate (53.1% in 2007, 51.7% in 2012 and 53.7% in 2017) [5]. In Kupang, Indonesia the minimum percentage of acceptable diet (MAD) for children aged 6-23 months is 42.1% [6]. Previous study showed that age of child, maternal characteristics (age, education level, marital status, and occupational status), number of family member, and household income had an influence on child complementary feeding practices [7-11].

In Indonesia, the prevalence of stunting remains relatively high. It reached 24.4 percent in 2021, which over the WHO standard at 20%. Moreover, the trend of underweight has also been increased from 2019 (16%) to 17 percent in 2021 [12]. Cikarang Timur is one of the regencies in Indonesia that still have child death caused by undernutrition. Even though the government has implemented a number of interventions since the early 2000s to guide and improve the complementary feeding practices for children. A number of children who suffer from malnutrition is still exist.

Therefore, this study aimed to examine the CF practices based on WHO Indicators for IYCF, and its associated factors among mothers of children aged 6 to 23 months old in Cikarang Timur, Indonesia

## 2. Methods

### 2.1. Study design and participants

This study is a cross-sectional survey conducted during July to Augusts 2022 in Cikarang Timur, West Java, Indonesia. Data were collected using a structured questionnaire through face-to-face interview. The total population of children aged 6 to 23 months old in this area were 3,608 children. The interview was conducted among 325 mothers, who had children aged 6 to 23 months. The minimum sample size was calculated using the Slovin's formula. The sample was chosen by simple random sampling technique among the household listing information obtained from the primary healthcare center. Only the household with 6 to 23 months old children selected to perform the random selection of households using Excel Random function. Later, the mothers who had lived in Cikarang Timur for the past 6 months, had a biological child aged 6 to 23 months old, and able to communicate in Indonesian language were invited to participate in the study. However, the mothers with a child aged between 6 to 23 months old with food allergies and birth defects or seriously ill were excluded. The study was implemented after obtaining approval from the Ethics Committee of the Faculty of Public Health, Sriwijaya University (300/UN9.FKM/TU.KKE/2022).

### 2.2. Measurement of variables

Data on children characteristics and maternal characteristics were collected using a structured questionnaire through face-to-face interview. Data on children characteristics included age, sex, and birth weight and length. Maternal characteristics included age, educational level, marital status, ethnicity, religion, occupational status, and household income.

CF practices were measured using a structured questionnaire obtaining from WHO for assessing Infant and Young Child Feeding practices (IYCF) [2]. The complementary feeding indicators were measured including 1) Introduction to solid, semi-solid and liquid food at the age of 6-8 months; 2) Minimum dietary diversity (MDD) for child aged 6-23 months who consumed  $\geq 5$  out of 8 food groups; 3) Minimum meal frequency (MMF) for child aged 6-23 months

Table 1. Children and maternal characteristics, and complementary feeding practices indicators.

Variables	Frequency	Percentage
<b>Children characteristics</b>		
Sex of the child		
Male	186	57.2
Female	139	42.8
Birth weight		
< 2500 gram	37	11.4
≥ 2500 gram	288	88.6
Birth length		
< 48 cm	11	3.4
≥ 48 cm	314	96.6
Age of the child (in months)		
6-11	149	45.8
12-17	99	30.5
18-23	77	23.7
<b>Maternal characteristics</b>		
Age		
< 20 years old	46	14.2
≥ 20 years old	279	85.8
<b>Educational level</b>		
Primary	92	28.3
Secondary and above	232	71.4
<b>Marital Status</b>		
Married	310	95.4
Divorced	15	4.6
<b>Ethnicity</b>		
Sundanese	246	75.7
Other	79	24.3
<b>Religion</b>		
Muslim	307	94.5
Others (Protestant and Catholic)	18	5.5
<b>Occupational status</b>		
Employed	14	4.3
Unemployed	311	95.7
<b>Household characteristics</b>		
Number of family member		
≤ 4 members	260	80
> 4 members	65	20
Family Structure		
Nuclear family	277	85.2
Extended family	31	9.5
Others	17	5.2
Household Income		
Low income	236	72.6
High income	89	27.4
<b>Complementary feeding practices</b>		
ISSF		
Yes	83	100%
No	0	0
MMF		
Yes	251	77.2
No	74	22.8
MDD		
Yes	167	51.4
No	158	48.6
MAD		
Yes	124	38.2
No	201	61.8

received a meal with standard frequency; and 4) Minimum Acceptable Diet (MAD) for child aged 6-23 who received a meal meet standard for dietary diversity and frequency. Back translation was performed to control the quality of the questionnaire. All indicators were evaluated according to WHO recommendations [2]. The validity of questionnaire had been tested by three experts and scored  $\geq 0.7$ . Cronbach's Alpha coefficient of the questionnaire was  $\geq 0.8$ .

### 2.3. Data management and analyze

Data were collected, cleaned, and coded onto Microsoft Excel, and were entered into Statistical Package for the Social Sciences (SPSS) version 28. Chi-square was performed to examine the association between independent variables (children characteristics and maternal characteristics) and dependent variables complementary feeding practices (MDD, MMF, and MAD). Multiple logistic regression was used to determine the risk factors associated with complementary feeding practices of children aged 6 to 23 months old. Statistical significance level was set at  $< 0.05$ . Odd ratio (OR) and 95% confident interval (CI) were reported.

## 3. Result

### 3.1. Children characteristics and maternal characteristics

The characteristics of children and the mothers are listed in Table 1. It shows that more than half of children in this study were male (57.2%), aged between 6-11 months old. Only 37 children (11.4%) had low birth weight, and 11 children (3.4%) had a birth length  $< 48$  cm. Whereas, majority of the mothers (71.4%) had secondary education and above, aged  $\geq 20$  years old (85.8%), unemployed (95.7%), and married (95.4%). Most of the families in this study were Sundanese, and diverse Muslims. About 85% of children were from a nucleus family. Additionally, 72.6% of families had low income.

### 3.2. Complementary feeding practices in children aged 6-23 months old

The CF practices of the children aged 6-23 months are shown in Table 1. It shows that

Table 2. Chi-square analysis of complementary feeding practices indicators with children and maternal characteristics.

Characteristics	MMF			MDD			MAD			P-value			
	No	Yes	P-value	No	Yes	P-value	No	Yes	P-value				
	N	n		%	n		%	n			%	n	%
<b>Sex of the child</b>													
Male	44	59.5	142	56.6	92	58.2	94	56.3	111	55.2	75	60.5	0.352
Female	30	40.5	109	43.4	66	41.8	73	43.7	90	44.8	49	39.5	
<b>Birth weight</b>													
< 2500 gram	12	16.2	25	10	23	14.6	14	8.4	31	15.4	6	4.8	0.004*
≥ 2500 gram	62	83.8	226	90	135	85.4	153	91.6	170	84.6	118	95.2	
<b>Birth length</b>													
< 48 cm	3	4.1	8	3.2	5	3.2	6	3.6	8	4	3	2.4	0.450
≥ 48 cm	71	95.9	243	96.8	153	96.8	161	96.4	193	96	121	97.6	
<b>Age of the child (in month)</b>													
6-11	31	41.9	118	47	79	50	70	41.9	95	47.3	54	43.5	0.425
12-17	22	29.7	77	30.7	40	25.3	59	35.3	56	27.9	43	34.7	
18-23	21	28.4	56	22.3	39	24.7	38	22.8	50	24.9	27	21.8	0.005*
<b>Educational level</b>													
Primary	22	29.7	70	27.9	53	33.5	39	23.4	68	33.8	24	19.4	0.225
Secondary and above	52	70.3	181	72.1	105	66.5	128	76.6	133	66.2	99	80.6	0.075
<b>Marital Status</b>													
Married	70	94.6	240	95.6	153	96.8	157	94	195	97	115	92.7	0.009*
Divorced	4	5.4	11	4.4	5	3.2	10	6	6	3	9	7.3	
<b>Ethnicity</b>													
Sundanese	54	73	192	76.5	136	86.1	110	65.9	162	80.6	84	67.7	0.002*
Other	20	27	59	23.5	22	13.9	57	34.1	39	19.4	40	32.3	
<b>Religion</b>													
Muslim	66	89.2	241	96	156	98.7	151	90.4	196	97.5	111	89.5	0.848
Others (Protestant and Catholic)	8	10.8	10	4	2	1.3	16	9.6	5	2.5	13	10.5	
<b>Occupational status</b>													
Employed	3	4.1	11	4.4	2	1.3	12	7.2	9	4.5	5	4	0.009*
Unemployed	71	95.9	240	95.6	156	98.7	155	92.8	192	95.5	119	96	0.912
<b>Number of family member</b>													
≤ 4 members	57	77	203	80.9	126	79.7	134	80.2	159	79.1	101	81.5	0.607
> 4 members	17	23	48	19.1	32	20.3	33	19.8	42	20.9	23	18.5	

Table 2. Chi-square analysis of complementary feeding practices indicators with children and maternal characteristics. (cont.)

Characteristics	MMF			MDD			MAD		
	No	Yes	P-value	No	Yes	P-value	No	Yes	P-value
	N	n	%	n	n	%	n	n	%
<b>Family Structure</b>			0.873			0.263			0.067
Nuclear family	64	213	84.9	138	139	87.3	176	101	87.6
Extended family	7	24	9.6	15	16	9.5	19	12	9.5
Others	3	14	5.6	5	12	3.2	6	11	3.0
<b>Household Income</b>			0.417			0.855			0.806
Low income	51	185	73.7	114	122	48.3	145	91	72.1
High income	23	66	26.3	44	45	27.8	58	33	27.9

\*p-value <0.05

Table 3. Factors associated with complementary feeding practices indicators.

Characteristics	MMF			MDD			MAD		
	AOR	(95% CI)	p-value	AOR	(95% CI)	p-value	AOR	(95% CI)	p-value
<b>Birth weight</b>									
< 2500 gram	-	-	-	-	-	-	1	-	-
≥ 2500 gram	-	-	-	-	-	-	1.992	(0.946-4.197)	0.070
<b>Educational level</b>									
Primary	-	-	-	1	-	-	1	-	-
Secondary and above	-	-	-	1.627	(0.970-2.730)	0.065	1.690	(1.008-2.835)	0.047
<b>Ethnicity</b>									
Sundanese	-	-	-	1	-	-	1	-	-
Other	-	-	-	2.737	(1.486-5.044)	0.001	3.033	(1.632-5.638)	<0.001
<b>Religion</b>									
Muslim	3.009	(1.134-7.983)	0.027	1	-	-	1	-	-
Others (Protestant and Catholic)	1	-	-	3.611	(0.745-17.501)	0.111	3.063	(0.626-14.984)	0.167
<b>Occupational status</b>									
Employed	-	-	-	5.587	(1.203-25.944)	0.028	-	-	-
Unemployed	-	-	-	1	-	-	-	-	-
	R <sup>2</sup> 0.022			R <sup>2</sup> 0.132			R <sup>2</sup> 0.120		

the majority of the children received inappropriate CF practices for MDD, MAD, and MMF. Nevertheless, more than half children (51.3%) achieved minimum dietary diversity (MDD), and more than one-third (38.1%) fulfilled the MAD. Moreover, 77.2% of children met the recommended MMF. Interestingly, all children received ISSF.

### 3.3. Complementary feeding practice of children aged 6-23 months

The Chi-square analysis results are shown in Table 2. The results show that only religion was associated with MMF ( $p = 0.039$ ). While educational level ( $p = 0.042$ ), ethnicity ( $p < 0.001$ ), religion ( $p = 0.001$ ), and occupational status ( $p = 0.009$ ) were found to be associated with MDD. For MAD, the significant association were found among children's birth weight ( $p = 0.004$ ), educational level ( $p = 0.005$ ), ethnicity ( $p = 0.009$ ), and religion ( $p = 0.002$ ).

### 3.4. Factors associated with complementary feeding practices among children aged 6-23 months

Further analyses with multiple logistic regression found that Muslim mothers had 3.01 higher odds of practicing the MMF (AOR 3.01. 95% CI: 1.13-7.98). For MDD indicators, the result show that mother with other ethnicity than Sundanese and employed mother had 2.74 odds and 5.59 odds higher in practicing dietary diversity to their child (AOR 2.74. 95% CI: 1.49-5.04; AOR 5.59. 95% CI 1.20-25.94), respectively. Similar results were observed for practicing MAD, mother with other ethnicity than Sundanese were 3.03 higher odd of practicing MAD (AOR 3.03. 95% CI: 1.63-5.64), and mothers who had secondary education and above were 1.69 higher odds of practicing MAD. (Table 3)

## 4. Discussion

From the nine indicators set by WHO [2, 13], this study focuses on four core indicators in assessing CF practice aged 6-23 months, which are ISSSF, MDD, MMF, and MAD. This study revealed that mothers were implement feeding practice according to the recommendations of the ISSSF and MMF indicators of above 70%. This

result was similar with a study conducted by Ahmad in Aceh Indonesia findings that MMF practices in that area reached to 74% but only 50% mothers practicing for the timely introduction of solid, semi-solid and soft food [14]. Another study in Latin American and the Caribbean showed that ISSSF was best performed among other four indicators of complementary feeding studied, from 10 out of 11 countries that evaluated, the prevalence of ISSSF above 80%. Next, performance by MMF was moderate, with 4 countries out of 14 showing prevalence above 80% [15].

The proportions of children receiving MDD and MAD were still very low at 51.4% and 38.2%, respectively. The results of this proportion are in line with several studies conducted in several different regions in Indonesia [14, 16, 17]. As research results conducted in Sumedang Indonesia, the proportion MDD and MAD were only 32.8% [16], and MDD and MAD were 49.7% and 39.8%, respectively in Aceh Indonesia [16]. Based on Indonesian national survey from DHS in 2017, the prevalence of MAD was only 26% which consists of 72% MDD and 29.8% MDD [17].

Child feeding must adhere to MMF and MDD standards. The minimum meal frequency standard for daily consumption for children aged 6-8 months was  $\geq 2$  times, for age 9-23 months  $\geq 3$  times, and  $\geq 4$  times for non-breastfed children with a minimal diversity of 5 of out 8 groups. Based on this indicator, this study showed that 7 out of 10 children (77.2%) met the MMF, but with poor dietary diversity (51.3%). When compared to the standard of MAD with the criteria of both the frequency and diversity, almost 4 out of children (38.1%) met the criteria.

Numerous factors contributed to the inappropriate or poor CF practice of children aged 6 to 23 months. Study in rural area in Southern Berlin found that complementary feeding practices were positively associated with child's age but not with socioeconomics factors such as mother's education, ethnicity and employment status [18]. A study found that poor CF practice, particularly on MDD and MAD, was influenced by younger age (6-11 months old), mother's age, low socioeconomic status, and poor health and

nutrition services [19]. On the other hand, the mother's knowledge, perception, attitude, belief, and skill, as well as the health service and the home environment, were related to the CF practice of children older than 6 months old [20].

However, social norms and cultural aspects of the society also had an impact on CF practice. The low percentage of proper CF practice in Aceh was attributed to socio-cultural aspects of the local community, such as the introduction of food taste to newborns at the age of seven days by giving honey, sugar, salt, and fruit extract [21].

This study found a significant association between mother's religion with the odds of MMF. In addition, the mother's occupation status and ethnicity were significantly associated with the odds of MDD. Similarly, mother's ethnicity and religion were also associated with the odds of MAD. However, this study found no association on the age of child, mother's educational level, number of family, family structure and household income.

## 5. Conclusion

In summary, CF practices of children aged 6-23 months were sub-optimal. Among nine indicators of CF practices recommended by WHO, only MMF had high proportion (77.2%). The other indicators, namely MDD and MAD. Suboptimal CF practices were found among children aged 6-23 months old in Cikarang Timur, Indonesia. These findings shows that a positive association between mother's education level and MAD practicing.

The findings of this study may provide and use as a baseline information to develop a guide for nutritional education programs to enhance CF practices, and can also be compared across regions in terms of CF practices among children between the ages of 6 and 23 months.

## Recommendation

Strengthening national policies to educate women at least to the secondary level might be a cost-effective intervention for improving IYCF practices. These results highlight the need to increase the knowledge and CF practice of the mothers in the area through a specific training on

food preparation skills, and maximizing food processing according to local ingredients, practices, and culture. In addition, the training should also emphasize on the frequency, variation, preparation, and processing food to infants and children in accordance with WHO recommendations for infant and young child feeding practices.

## Acknowledgements

We are grateful to the 325 mothers of children aged 6-23 months old of the participants, to the research assistant and nutrition staff at Lemahabang Public Health Center for their support and help in data collection.

## References

- [1] Dewey KG, Vitta BS. Strategies for ensuring adequate nutrient intake for infants and young children during the period of complementary feeding. Washington D.C.: Alive & Thrive; 2013.
- [2] World Health Organization [WHO]. Indicator for assessing infant and young child feeding practice. [cited 2022 May 16]. Available from <https://www.who.int/publications/i/item/9789240018389>
- [3] World Health Organization [WHO]. Global strategy for infant and young child feeding. Geneva: WHO; 2003.
- [4] World Health Organization [WHO]. Infant and young child feeding. [cited 2018 January 16]. Available from: <https://www.who.int/news-room/fact-sheets/detail/infant-and-young-child-feeding>
- [5] Paramashanti BA, Huda TM, Alam A, Dibley MJ. Trends and determinants of minimum dietary diversity among children aged 6-23 months: a pooled analysis of Indonesia Demographic and Health Surveys from 2007 to 2017. *Public Health Nutr.* 2022; 25(7): 1956-67. doi: 10.1017/S1368980021004559
- [6] Thobias IA, Djokosujono K. Keragaman Makan Minimum Sebagai Faktor Dominan Stunting Pada Anak Usia 6-23 Bulan Di Kabupaten Kupang. *Jurnal Kesmas dan Gizi (JKG).* 2021; 3(2): 136-43. doi: 10.35451/jkg.v3i2.592
- [7] Mekonnen TC, Workie SB, Yimer TM, Mersha WF. Meal frequency and dietary diversity feeding practices among children 6-23 months

- of age in Wolaita Sodo town, Southern Ethiopia. *J Health Popul Nutr.* 2017; 36(1): 18. doi: 10.1186/s41043-017-0097-x
- [8] Solomon D, Aderaw Z, Tegegne TK. Minimum dietary diversity and associated factors among children aged 6-23 months in Addis Ababa, Ethiopia. *Int J Equity Health.* 2017; 16(1): 181. doi: 10.1186/s12939-017-0680-1
- [9] Gatahun EA, Demissie M, Abyu DM. Dietary diversity feeding practice and determinants among children aged 6-23 months in Kemba Woreda, Southern Ethiopia implication for public health intervention. *J Nutr Food Sci.* 2015; S13. doi: 10.4172/2155-9600.S13-003
- [10] Issaka AI, Agho KE, Burns P, Page A, Dibley MJ. Determinants of inadequate complementary feeding practices among children aged 6-23 months in Ghana. *Public Health Nutr.* 2015; 18(4): 669-78. doi: 10.1017/s1368980014000834
- [11] Semahegn A, Tesfaye G, Bogale A. Complementary feeding practice of mothers and associated factors in Hiwot Fana Specialized Hospital, Eastern Ethiopia. *Pan Afr Med J.* 2014; 18: 143. doi: 10.11604/pamj.2014.18.143.3496
- [12] Kemenkes RI. *Survei Status Gizi Balita Indonesia (SSGBI).* Jakarta: Kemenkes RI; 2021.
- [13] Lassi ZS, Rind F, Irfan O, Hadi R, Das JK, Bhutta ZA. Impact of infant and young child feeding (IYCF) nutrition interventions on breastfeeding practices, growth and mortality in low- and middle-income countries: Systematic review. *Nutrients.* 2020; 12(3). doi: 10.3390/nu12030722
- [14] Ahmad A, Madaniyah S, Dwiriani CM, Kolopaking R. Complementary feeding practices and nutritional status of children 6-23 months old: formative study in Aceh, Indonesia. *Nutr Res Pract.* 2018; 12(6): 512-20. doi: 10.4162/nrp.2018.12.6.512
- [15] Cavalcanti AUA, Boccolini CS. Social inequalities and complementary feeding in Latin America and the Caribbean. *Cien Saude Colet.* 2022; 27(2): 619-30. doi: 10.1590/1413-81232022272.31862020
- [16] Diana A, Mallard SR, Haszard JJ, Purnamasari DM, Nurulazmi I, Herliani PD, et al. Consumption of fortified infant foods reduces dietary diversity but has a positive effect on subsequent growth in infants from Sumedang district, Indonesia. *PLoS One.* 2017; 12(4): e0175952. doi: 10.1371/journal.pone.0175952
- [17] National Population and Family Planning Board [BKKBN]; Statistics Indonesia [BPS]; Ministry of Health [Kemenkes]; ICF. *Indonesia demographic and health survey 2017.* Jakarta: BKKBN, BPS, Kemenkes, and ICF; 2018.
- [18] Bodjrenou FSU, Amoussa Hounkpatin W, Termote C, Dato G, Savy M. Determining factors associated with breastfeeding and complementary feeding practices in rural Southern Benin. *Food Sci Nutr.* 2021; 9(1): 135-44. doi: 10.1002/fsn3.1971
- [19] Na M, Aguayo VM, Arimond M, Stewart CP. Risk factors of poor complementary feeding practices in Pakistani children aged 6-23 months: A multilevel analysis of the Demographic and Health Survey 2012-2013. *Matern Child Nutr.* 2017; 13(Suppl 2): e12463. doi: 10.1111/mcn.12463
- [20] Blaney S, Februhartanty J, Sukotjo S. Feeding practices among Indonesian children above six months of age: a literature review on their potential determinants (part 2). *Asia Pac J Clin Nutr.* 2015; 24(1): 28-37. doi: 10.6133/apjcn.2015.24.1.14
- [21] Zahrina C, Ag S. Ritual masyarakat aceh dalam menyambut kelahiran anak (suatu tinjauan kekinian). [cited 2022 September 18]. Available from: <http://gerbangaceh.blogspot.co.id/2007/12/ritualmasyarakat-aceh-dalam-menyambut.html>

# Heavy Metals Contamination in Local White Rice: A Preliminary Study at Palembang, South Sumatra, Indonesia

Dian Islamiati <sup>a, \*</sup>, Pokkate Wongsasuluk <sup>a, b</sup>

<sup>a</sup> College of Public Health Sciences, Chulalongkorn University

<sup>b</sup> Health and Social Sciences and Addiction Research Unit (HSSRU), Thailand

## Abstract

**Background:** Heavy metal pollution is still one of the environmental concerns in society. The contamination can be through water, soil, air, and food. One of them is heavy metal contamination in paddy fields and rice. Heavy metal pollution in agricultural products such as rice comes from the use of pesticides, fertilizers, and natural soil with pH conditions. White rice is a commonly eaten rice type by people in Indonesia, especially the people of Palembang. The consumption of rice can be a source of heavy metal contamination in the community. Heavy metals contaminations were known have the impact on human health. Some study was found health risks related to heavy metals contamination in rice. This study aims (1) To determine the concentration of heavy metals and (2) To find the non-carcinogenic and carcinogenic risks from local white rice consumption in Palembang, South Sumatra, Indonesia.

**Method:** Rice was collected from the three largest local markets in the city of Palembang with a total sample of 6 local white rice samples, 100 mg/sample. There were 2 types of local white rice that commonly consume namely Pandan Wangi and Pulen rice. The initial stage of the analysis was sample preparation where the rice is transformed into a flour-like shape, then followed by the digestion stage. The final stage was the analysis of heavy metals in rice using the inductively coupled plasma optical emission spectrometry (ICP-OES) method. The laboratory analysis results were used to calculate potential risk. The Potential risk was calculated used the environmental health risk assessment method which was the subject data used secondary data from the health risk assessment guideline from Indonesia.

**Results:** The results of both Pandan Wangi and Pulen rice showed all the concentrations of arsenic (As), cadmium (Cd), lead (Pb), and copper (Cu) were below the detection limit. All rice samples found As, Cd, and Pb lower than standard, which were 0.800 ug/gr, 0.038 ug/gr, and 0.839 ug/gr, respectively. Meanwhile, copper (Cu) was found in Pandan Wangi rice with an average concentration of 0.89 ug/gr, ranging from 0.26 to 1.62 ug/gr. In Pulen rice, copper (Cu) was found with an average concentration of 1.12 ug/gr, ranging from 0.95 to 1.17 ug/gr. Risk assessments showed there was a non-carcinogenic effect for adults and kids which HI were 12.844 and 9.418 respectively for Pandan wangi rice and 12.846 and 9.420 respectively for Pulen rice. On other hand, the assessment showed the same results of TCR between Pandan wangi rice and Pulen rice. The results showed there was a carcinogenic risk, in which TCR were  $8.03 \times 10^{-3}$  for adults and  $2.94 \times 10^{-2}$  for kids.

**Conclusion:** Risk assessment showed that both types of rice have potential risk even though the concentrations of rice were lower than standard. Health risks in kids were known to be higher than in adults. Heavy metals in rice should be reduced by controlling the use of pesticides and fertilizers during the rice planting process. In addition, people in Palembang might be reduced the amount of rice consumption to reduce health risks.

**Keywords:** Heavy metal, Contamination, Rice, Indonesia

## 1. Introduction

Heavy metal pollution is still a problem in the

world, including in Indonesia. Various sources of heavy metal pollution and natural conditions are

\* Corresponding author.

E-mail address: dianislamiati2501@gmail.com (Dian Islamiati)

the factors for water, water, soil, and agricultural products pollution. Sources of heavy metal pollution also come from human activities. Cadmium is known to come from cigarettes, fossil fuels, and fertilizers [1]. In addition, heavy metal contamination of lead is also known to come from the printing of books, and the reuse of batteries and shades [2]. Heavy metal contamination can be through three pathways, including inhalation, dermal and oral. Heavy metal contamination through these various pathways will go to target organs based on risk agents that enter the body. Contamination through inhalation can come from contaminated air which is then inhaled, while contamination through dermal can come from activities touching soil or water contaminated with risk agents such as heavy metal contamination [3].

Besides that, contamination of agent risk such as heavy metals also found through an oral pathway. One of the oral contaminations is found in food, specifically rice. One of the causes of heavy metal pollution in rice is the use of pesticides at the time of planting [4]. In addition, it is known that the use of fertilizers has an impact on the concentration of heavy metals in agricultural soils and agricultural products [5]. The presence of heavy metals is also naturally influenced by soil pH conditions [6]. Some of these sources are the cause of heavy metal contamination in both agricultural land and rice. The use of pesticides causes the pesticide to fall on the leaves, and other parts of the plant and, the soil. Plant roots are known to absorb contaminants that have an impact on agricultural products [7-9]. A study in China found the heavy metal arsenic in rice with concentrations exceeding the safe limit [10]. In addition, a study in Vietnam found contamination of arsenic, cadmium, lead, and copper in rice from mining areas [11]. A study in Indonesia itself showed that the concentration of arsenic in white rice exceeds safe standards [12].

The consumption of rice which contains heavy metals in small concentrations in large quantities is known to have an impact on health problems. Although the concentration of heavy metals is found in small amounts, the level of

toxicity is known to be high. Arsenic contamination is known to cause acute and long-term health problems [13]. In addition, it can cause muscle cramps, abdominal pain, and an irregular heartbeat [14]. On the other hand, rice is a food commonly consumed by people in Indonesia, especially in Palembang. According to data from the statistical agency in 2017, Indonesian people's rice consumption reaches 200-350 grams per day per person [15]. There are two types of rice that are usually consumed by the people of Palembang, namely Pule rice and Pandan wangi rice. Consumption of this large amount can be one of the potential risks to public health. Study in Indonesia found the carcinogenic risk related arsenic exposure in white rice [12, 16]. Therefore, a study were needed to determine the concentration of heavy metals, calculate non-carcinogenic risk and carcinogenic risk in local white rice in Palembang, South Sumatra.

## 2. Methods

This research was a preliminary study conducted in Palembang, South Sumatra, Indonesia. Palembang is the capital city of South Sumatra, which is located in the south part of Sumatra Island. Rice is known to be the staple food of the people in the city of Palembang. The two types of rice commonly consumed by the people of Palembang are Pule rice and Pandan Wangi rice. The samples used were collected from the 3 largest markets in the city of Palembang. The three biggest markets are located in the right area, the middle area, and the left area of the Musi River in Palembang. Musi River is a river that divides Palembang city to be three areas. Shop was chosen by random sampling in each market. Each shop collected two types of rice with the total sample was 6 sample. Rice was sent to the Health Laboratory Center of Palembang. 100 grams of rice samples were sent.

The initial stage of analysis was sample preparation. At this stage, the rice was converted into a smaller form such as flour [17]. Rice was washed with deionized water and dried at 70-100 C using a microwave. The next stage is the digestion stage. This stage changes the sample from compounds to elements. Then 0.5 gram

sample was mixed with 5mL HNO<sub>3</sub> and 1 ml HCl which was then put into the microwave at 200°C for 15 minutes. After this step was completed, the sample was transferred to a 50 mL volumetric flask and supplemented with ultrapure water [18]. The final stage was heavy metal analysis with inductively coupled plasma (ICP-OES). This stage uses electric and magnetic as energy sources by using special tools and gases. With this method, multi-heavy metal analysis can be carried out in a relatively fast time.

The potential risk was calculated with certain formula. Laboratory analysis results and subject data from secondary data were used to calculate the non-carcinogenic risk and carcinogenic risk. The average daily dose was calculated with the following formula [19] :  $ADD = C \times IR \times ED \times EF / Wb \times AT$ . The average daily dose (ADD) is used for non-carcinogenic calculation, meanwhile the carcinogenic use lifetime average daily dose (LADD). After the average daily dose was

calculated, the potential risk for non-carcinogenic risk was calculated with :  $HQ = ADD/RfD$  and  $HI = \Sigma HQ$  if the results of both values were more than one, it indicates there may be non-carcinogenic risk related heavy metals contaminations in local white rice. The cancer risk was calculated with  $CR = LADD \times SF$  and  $TCR = \Sigma CR$  if the results of both values were more than  $1 \times 10^{-6}$ , it indicates there may be carcinogenic risk related heavy metals contaminations in local white rice [20].

### 3. Results

#### 3.1. Type of rice.

Rice is commonly eaten food daily by the people in Palembang. Based on the survey results, Palembang people consume rice 2-3 times a day on average. The types of rice consumed were Pandan wangi rice and Pulen rice. Fig. 1 shows the picture of the two types of rice namely Pandan wangi rice (a), Pulen rice (b) and comparison of two rice (c).

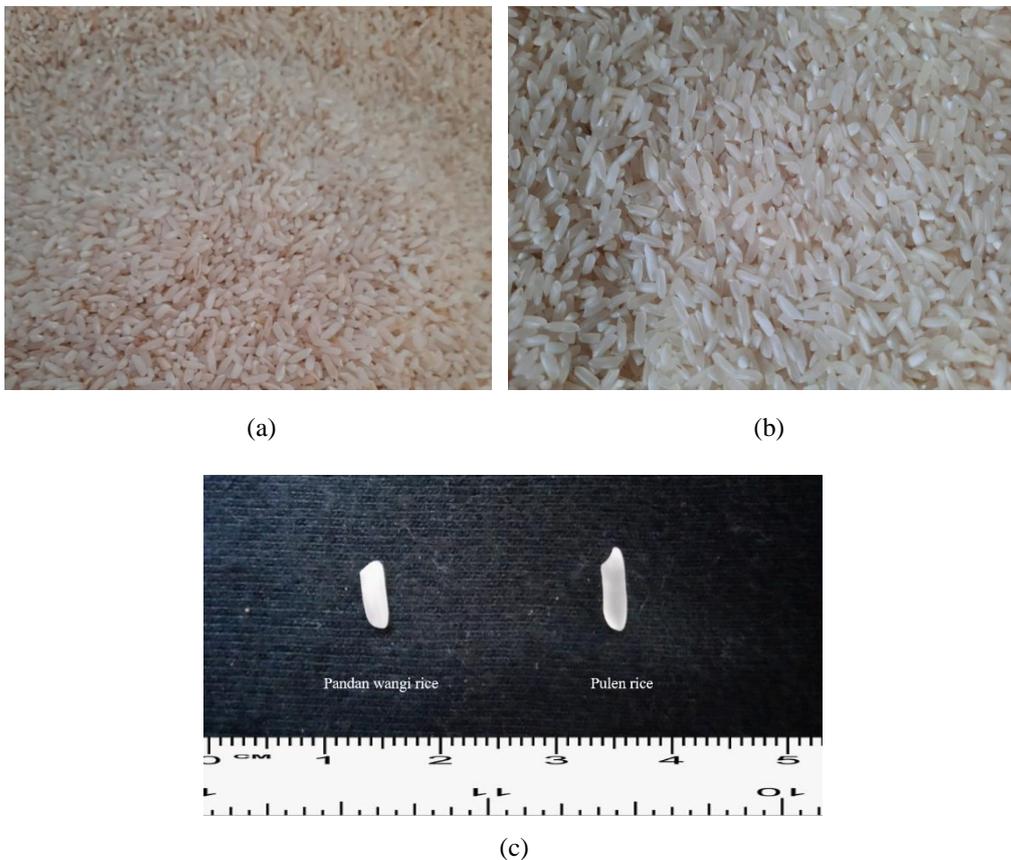


Fig. 1. Type of rice  
(source: Primary data from research observation)

Table 1. Concentrations of heavy metals

Type of Rice	As (ug/gr)	Cd (ug/gr)	Pb (ug/gr)	Cu (ug/gr)
Pandan wangi	<0.800	<0.038	<0.839	0.255 <sup>1</sup>
	<0.800	<0.038	<0.839	0.792 <sup>2</sup>
	<0.800	<0.038	<0.839	1.616 <sup>3</sup>
Pulen	<0.800	<0.038	<0.839	0.950 <sup>1</sup>
	<0.800	<0.038	<0.839	1.230 <sup>2</sup>
	<0.800	<0.038	<0.839	1.174 <sup>3</sup>
Mean	<0.800	<0.038	<0.839	1.00

Note: 1= first market, 2= second market, and 3= third market

Based on the physical form, there was no significant difference between the two types of rice. From the picture above (c), we can see the different between this types of rice. Left side was Pandan wangi rice and right side was Pulen rice. Both rice were cylindrical. However, the shape of Pandan wangi rice tends to be incomplete or not perfectly cylindrical and shorter than Pulen rice. In addition, in terms of color, Pulen rice was known to have a whiter color or transparent than Pandan wangi rice. The quality of Pulen rice was known to be better than Pandan wangi rice. The price of Pulen rice was also known to be more expensive than Pandan wangi rice. The most noticeable difference was when the rice was cooked. Raw Pulen rice will increase 2.1 times after cooking, while Pandan wangi rice will increase 1.8 times after cooking. In addition, Pandan wangi rice has a pandan aroma after cooking. Meanwhile, Pulen rice has a fluffier texture when cooked.

### 3.2. The concentration of heavy metals

Heavy metal contamination in rice was known to be found in rice. Some study found heavy metals in rice and known have potential risk to human. There are four heavy metals that are commonly found in heavy metals, including arsenic (As), cadmium (Cd), lead (Pb), and copper (Cu). Table 1 shown the results of the analysis of these four heavy metals.

Based on the analysis above, shows that the concentrations of three heavy metals, namely arsenic (As), cadmium (Cd), and lead (Pb) were below the detection limit using the ICP-OES tool.

Generally, the Limit of Detection (LOD) for arsenic and lead in the ICP-OES method is 25-50 ug/gr. Meanwhile, cadmium has a lower detection limit of 2.5-5 ug/gr. This heavy metal detection limit value was obtained from the results of repeated analyzes and related to the conditions at the time of analysis. In the results of this analysis, the detection limit of three heavy metals was lower than the LOD value in general. For heavy metals arsenic and lead, the concentrations were known to be below 0.800 ug/gr and 0.839 ug/gr, respectively. While in cadmium the concentration of heavy metals was below the LOD of 0.038 ug/gr.

On the other hand, copper was known to be above the detection limit but remains within safe limits. The average concentration of copper in Pulen rice is known to be 1.12 ug/gr and in Pandan wangi rice it is 0.89 ug/gr. The concentration of Pulen rice was known 1.2 times higher than Pandan wangi rice. The highest concentration of Pulen rice was obtained from market B with a concentration of 1,230 ug/gr and the lowest in market A at 0.950 ug/gr. Meanwhile, in Pandan Wangi rice, the highest copper concentration was obtained from market C at 1.616 ug/gr and the lowest from market A at 0.255 ug/gr.

### 3.3. Risk Assessment

Environmental health risk assessment is a method used to predict health risks due to exposure to chemical agents from water, soil, food and air. This method predicts non-carcinogenic and carcinogenic health risks. Health risks due to consumption of rice containing

Table 2. Parameter

Parameter	Symbol	Unit	Default Number	Reference
Concentration	C	ug/gr	Table 1	This study analysis
Ingestion Rate	IR	kg/day	0.25	BPS, 2017 [15]
Exposure day	ED	Years	Adults : 30 Kids : 6	Pedoman ARKL (Environmental Health Risk Assessment Guideline), 2012 [21]
Exposure frequency	EF	days/year	350 days/year	Pedoman ARKL (Environmental Health Risk Assessment Guideline), 2012
Weight	Wb	kg	Adults : 55 Kids : 15	Pedoman ARKL (Environmental Health Risk Assessment Guideline), 2012
Average time	AT	days	Non-carcinogenic : 10950 Carcinogenic : 25550	Pedoman ARKL (Environmental Health Risk Assessment Guideline), 2012
Reference dose	RfD	mg/kg.day	As : $3.0 \times 10^{-4}$ Pb : $3.5 \times 10^{-3}$ Cu : 0.37 Cd : $1.0 \times 10^{-3}$	US EPA, 2012 US EPA, 2012 US EPA, 2012 US EPA, 2012
Slope factor	SF	mg/kg.day <sup>-1</sup>	As : 1.5 Pb : $8.5 \times 10^{-3}$ Cu : N/A Cd : 15	US EPA, 2012 US EPA, 2012 - Zeng et al., 2015 [22]

Table 3. Risk assessments

		HQ (PW)	HQ (P)	CR (PW)	CR (P)
<b>As</b>	Adults	11.623	11.623	$5.23 \times 10^{-3}$	$5.23 \times 10^{-3}$
	Kid	8.524	8.524	$1.92 \times 10^{-2}$	$1.92 \times 10^{-2}$
<b>Pb</b>	Adults	1.045	1.045	$3.11 \times 10^{-4}$	$3.11 \times 10^{-4}$
	Kid	0.766	0.766	$1.14 \times 10^{-3}$	$1.14 \times 10^{-3}$
<b>Cu</b>	Adults	0.010	0.013	N/A	N/A
	Kid	0.008	0.010		
<b>Cd</b>	Adults	0.166	0.166	$2.48 \times 10^{-3}$	$2.48 \times 10^{-3}$
	Kid	0.121	0.121	$9.11 \times 10^{-3}$	$9.11 \times 10^{-3}$

heavy metals are not only influenced by the concentration of heavy metals but also other parameters. Table 2 shown the parameters used to conduct the assessment in this study.

Table 2, the risk assessment was calculated based on the type of rice for adults and children. Table 3 shown the results of the risk assessment of the four heavy metals.

From this table we can see that arsenic was only one heavy metals showed the value more than 1. We can see that arsenic only one heavy

metals which have the non-carcinogenic risk between four heavy metals. Meanwhile the hazard index showed the non-carcinogenic risk by consuming the two types of rice both for adults and kids by  $HI > 1$ . The value for Pandan wangi rice showed the risk for adults and kids as much as 12.844 and 9.418 respectively. There was a slight difference with Pulen rice where the HI values are 12.846 and 9.42 in adults and children, respectively. On other hand the total cancer risk (TCR) showed the same value for the two types

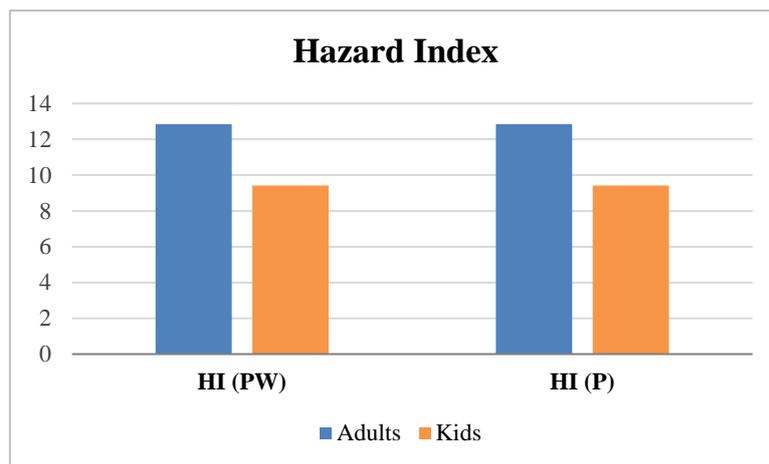


Fig. 2. Hazard Index

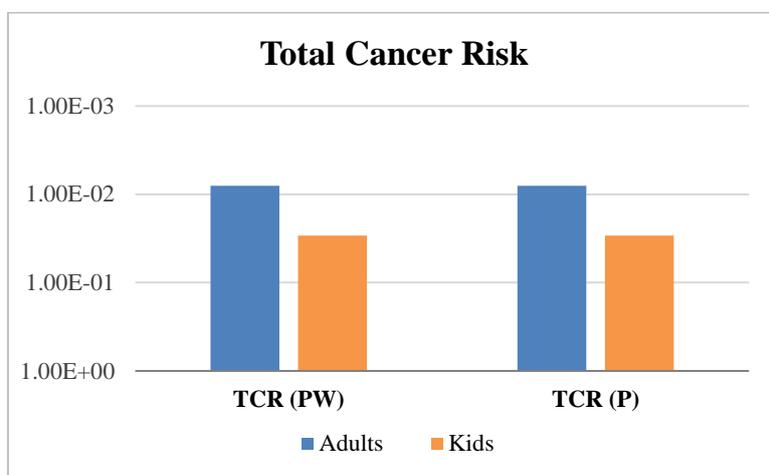


Fig. 3. Total Cancer Risk

of rice. The TCR were showed the value of  $8.03 \times 10^{-3}$  for adults and  $2.94 \times 10^{-2}$  for kids. The value was higher than standar for carcinogenic which were  $1 \times 10^{-6}$ . As we can see, the carcinogenic risk was higher in kids than in adults. (Fig. 2 and 3)

#### 4. Discussion

The concentration of heavy metals in rice in the city of Palembang was known to be still within safe limits. This was in line with previous studies where the arsenic concentration was found to be 0.06-0.30 mg/kg and was within the safe limit set by WHO, which was 0.3 mg/kg [23]. However, in this study, it was found that there was a potential risk due to rice consumption even though the arsenic concentration was still within the safe limit according to WHO [16]. As for the

heavy metal arsenic, the concentration is below the detection limit of the ICP-OES method. This was in contrast to research in Argentina, where arsenic was detected at concentrations of 0.87-3.16 mg/kg [24]. In addition to arsenic, lead concentrations are still below the detection limit. This contrasts with a study from Iran where the detected lead was very high, reaching 35 mg/kg [25]. This far exceeds the safe limit set by the WHO of 0.2 mg/kg [26].

The last heavy metal that below the detection limit is cadmium. The detection limit value of cadmium using the ICP-OES method was known to be the highest compared to other heavy metals. This study contrasts with previous studies where cadmium was detected at concentrations of 0.008-0.01 mg/kg [27]. However, this study and

previous studies both showed that the concentration of cadmium was within the safe limits set by WHO and the standard set by the Indonesian Standardization Agency of 0.4 mg/kg [26, 28]. Coppers was a metal whose detection rate is above the detection limit among the other three heavy metals. The finding of copper in rice is in line with the study in Indonesia. This study also shows that the concentration of heavy metal Cu was still in the safe limit with a concentration of 4.13-4.76 mg/kg [29]. It was known that the safe limit of copper concentration in rice is 20 mg/kg [30].

The both types of rices showed there were risk by consuming rice even the concentrations of heavy metals were lower than standard. On the other hand, health risks were not only influenced by heavy metal concentrations but are also influenced by the amount of rice consumption, frequency of exposure, duration of exposure to body weight. Duration of exposure, frequency of exposure and the amount of consumption per day are known to be directly proportional to health risks. The larger these values, the greater the potential risk that can occur [31]. On the other hand, weight were denominator in formula. The higher of weight, the lower risk will be occur [32]. The limitation of this research is the method used for analysis. The limit of detection using the ICP-OES method is known to be high. Three of the four heavy metals detected were below the LOD because the detection limit of ICP-OES was known to be higher than that of ICP-MS. In addition the subject data in this study used secondary data rather than used primary data from local people.

## 5. Conclusion

There were no significant differences between the two types of rice. The Pandan wangi rice was shorter than Pulen rice. For the colors, the pulen rice was whiter than Pandan wangi rice. Heavy metal analysis was carried out using the ICP-OES method. Through this preliminary study, heavy metal analysis was carried out, including arsenic (As), cadmium (Cd), lead (Pb), and copper (Cu). The results of the analysis showed that the

concentrations of arsenic (As), cadmium (Cd), and Lead (Pb) were below the detection limit, while the concentration of copper (Cu) was detected and still on safe limit. The highest HQ were from arsenic which only heavy metal which have a non-carcinogenic effect on health. The HI showed there were carcinogenic effects by consuming rice that was contaminated with four heavy metals. The highest CR were from arsenic. All heavy metals showed there was carcinogenic risk. The TCR showed that there were carcinogenic risk by consuming rice that was contaminated with four heavy metals.

## Recommendations

The concentration of heavy metals at safe limits must be maintained so that rice consumption does not pose a health risk to the community. Heavy metal analysis can also use the ICP-MS method for higher detection limits. Risk should be manage by reduce the concentrations of heavy metals in rice by controlling the use of pesticides and fertilizer in plating process. The risk might be reduced also by minimize the amount of rice consumption in one day. The study also used secondary data rather than primary data from Palembang people. Further studies can use questionnaires for personal data to be more in accordance with the assessment based on population. The potential risk results also showed there may be risk related heavy metals contaminations. The government should make clear regulations related pesticides and fertilizer used in paddy field to reduce heavy metals exposure in agricultural products. Indonesia government also need set standar regarding heavy metals safe standard in rice based on consumption of people rather than use international standard.

## Acknowledgments

The authors thankfully acknowledge the support of the College of Public Health Sciences, Chulalongkorn University, and the Health Laboratory Center of Palembang for their invaluable support in terms of scientific facilities and equipment.

## References

- [1] European Food Safety Authority [EFSA]. Cadmium in food - Scientific opinion of the Panel on Contaminants in the Food Chain. *EFSA Journal*. 2009; 7(3): 980. doi: 10.2903/j.efs.2009.980
- [2] Wani AL, Ara A, Usmani JA. Lead toxicity: a review. *Interdiscip Toxicol*. 2015; 8(2): 55-64. doi: 10.1515/intox-2015-0009
- [3] United States Environmental Protection Agency [US EPA]. Exposure assessment tools by routes-Inhalation 2021. [cited 2022 March 5]. Available from: <https://www.epa.gov/expobox/exposure-assessment-tools-routes-inhalation>.
- [4] Hooda PS. Trace elements in soils. London: Wiley; 2010.
- [5] Wei B, Yu J, Cao Z, Meng M, Yang L, Chen Q. The availability and accumulation of heavy metals in greenhouse soils associated with intensive fertilizer application. *Int J Environ Res Public Health*. 2020; 17(15): 5359. doi: 10.3390/ijerph17155359
- [6] Zhang J, Li H, Zhou Y, Dou L, Cai L, Mo L, et al. Bioavailability and soil-to-crop transfer of heavy metals in farmland soils: A case study in the Pearl River Delta, South China. *Environ Pollut*. 2018; 235: 710-9. doi: 10.1016/j.envpol.2017.12.106
- [7] Sharma A, Kumar V, Kumar R, Shahzad B, Thukral AK, Bhardwaj R. Brassinosteroid-mediated pesticide detoxification in plants: A mini-review. *Cogent Food Agric*. 2018; 4(1): 1436212. doi: 10.1080/23311932.2018.1436212
- [8] Sharma A, Kumar V, Thukral AK, Bhardwaj R. Responses of plants to pesticide toxicity: an overview. *Planta Daninha*. 2019; 37: e019184291. doi: 10.1590/S0100-83582019370100065
- [9] Alengebawy A, Abdelkhalek ST, Qureshi SR, Wang MQ. Heavy metals and pesticides toxicity in agricultural soil and plants: ecological risks and human health implications. *Toxics*. 2021; 9(3): 42. doi: 10.3390/toxics9030042
- [10] Chen B, Corns WT, Stockwell PB, Huang JH. Accurate fast screening for total and inorganic arsenic in rice grains using hydride generation atomic fluorescence spectrometry (HG-AFS). *Anal Methods*. 2014; 6(18): 7554-8. doi: 10.1039/c4ay00858h
- [11] Chu DB, Duong HT, Nguyet Luu MT, Vu-Thi HA, Ly BT, Loi VD. Arsenic and Heavy Metals in Vietnamese Rice: Assessment of Human Exposure to These Elements through Rice Consumption. *J Anal Methods Chem*. 2021; 2021: 6661955. doi: 10.1155/2021/6661955
- [12] Ginting EE. Analisis Arsen pada Berbagai Jenis Beras yang Beredar di Kota Medan dengan Spektrofotometri Serapan Atom. Medan: Universitas Sumatera Utara; 2018.
- [13] World Health Organization [WHO]. Arsenic 2018. [cited 2022 January 30]. Available from: <https://www.who.int/news-room/fact-sheets/detail/arsenic>.
- [14] Davis C. Arsenic poisoning. [cited 2022 February 26]. Available from: [http://www.medicinenet.com/arsenic\\_poisoning](http://www.medicinenet.com/arsenic_poisoning)
- [15] Badan Pusat Statistik [BPS]. Kajian Konsumsi Bahan Pokok 2017. BPS; 2018.
- [16] Saraswati IN. Analisis Arsen pada Beras dan Hasil Tanakannya secara Spektrofotometri Serapan Atom. Medan: Universitas Sumatera Utara; 2018.
- [17] Pizarro I, Gomez M, Palacios MA, Camara C. Evaluation of stability of arsenic species in rice. *Anal Bioanal Chem*. 2003; 376(1): 102-9. doi: 10.1007/s00216-003-1870-9
- [18] THERMO Scientific. Sample preparation techniques for AAS, ICP-OES and ICP-MS for regulated testing laboratories. THERMO Scientific; 2021.
- [19] Song D, Zhuang D, Jiang D, Fu J, Wang Q. Integrated health risk assessment of heavy metals in Suxian County, South China. *Int J Environ Res Public Health*. 2015; 12(7): 7100-17. doi: 10.3390/ijerph120707100
- [20] United States Environmental Protection Agency [US EPA]. Risk assessment guidance for superfund (Part E, Part F). Washington DC: EPA; 2011.
- [21] Menkes. Pedoman Analisis Risiko Kesehatan Lingkungan (ARKL). Jakarta: Kementerian Kesehatan; 2012.
- [22] Zeng F, Wei W, Li M, Huang R, Yang F, Duan Y. Heavy metal contamination in rice-producing soils of Hunan province, China and potential health risks. *Int J Environ Res Public Health*. 2015; 12(12): 15584-93. doi: 10.3390/ijerph121215005
- [23] US Food and Drug Administration [FDA]. Analytical results from inorganic arsenic in rice and rice products sampling September 2013. [cited 2022 January 30]. Available from: <https://www.fda.gov/media/86074/download>
- [24] Sigrist M, Hilbe N, Brusa L, Campagnoli D, Beldomenico H. Total arsenic in selected food

- samples from Argentina: Estimation of their contribution to inorganic arsenic dietary intake. *Food Chem.* 2016; 210: 96-101. doi: 10.1016/j.foodchem.2016.04.072
- [25] Fakhri Y, Bjorklund G, Bandpei AM, Chirumbolo S, Keramati H, Hosseini Pouya R, et al. Concentrations of arsenic and lead in rice (*Oryza sativa* L.) in Iran: A systematic review and carcinogenic risk assessment. *Food Chem Toxicol.* 2018; 113: 267-77. doi: 10.1016/j.fct.2018.01.018
- [26] World Health Organization [WHO]. Codex Alimentarius Commission. Report on the 11<sup>th</sup> session of the Codex Committee on Contaminants in Foods. WHO; 2017.
- [27] Taghi PB. Analisis Logam Berat Kadmium Pada Beras Dan Tanah Sawah Di Desa Loa Kecamatan Soa Kabupaten Ngada. Flore: Universitas Flores; 2021.
- [28] Standar Nasional Indonesia [SNI]. Batas maksimum cemaran logam berat dalam pangan. Jakarta: Badan Standarisasi Nasional; 2009.
- [29] Rasydy LOA, Sylvia D, Zein ZA. Analisis Logam Berat pada Beras (*Oriza Sativa* L.) yang Ditanam di Daerah Industri Karet Mekar Jaya. *Jurnal Farmagazine.* 2021; 8(1): 66-74.
- [30] World Health Organization [WHO]. Codex Alimentarius Commission. Codex Committee on Contaminants in Foods. WHO; 2014.
- [31] Bahar SN, Daud A, Indar. Risiko Paparan Arsen Pada Masyarakat Sekitar Sungai Pangkajene Kecamatan Bungoro Kabutan Pangkep. 2012; 4(2): 44-51.
- [32] Nukman A, Rahman A, Warouw S, Setiadi MI, Akib CR. Analisis Dan Manajemen Risiko Kesehatan Pencemaran Udara: Studi Kasus Di Sembilan Kota Besar Padat Transportasi. *Jurnal Ekologi Kesehatan.* 2005; 4(2): 270-89. doi: 10.22435/jek.v4i2 Agt.1634.

# Adaptation of Sustainable Healthy Settlement to Social-Cultural Life on Penyengat Island as a Cultural Reservation Area

Indra Martias<sup>a, \*</sup>, Rifardi<sup>a</sup>, Agrina<sup>a</sup>, Imam Suprayogi<sup>a</sup>, Syaza Halwa Amanina<sup>b</sup>

<sup>a</sup> Environmental Science Doctoral Program, Riau University, Pekanbaru, Indonesia,

<sup>b</sup> The Ministry of Health Polytechnic Tanjungpinang, Indonesia

## Abstract

**Background:** Penyengat Island is a small island that is thick with cultural values and has been set as a cultural heritage by the government of the Republic of Indonesia. The problem in the arrangement of healthy settlements on Penyengat Island is that some residents have built settlements in the former remnants of existing cultural heritage buildings. This is due to the increase in population, resulting in increased population settlements that threaten the existence of cultural heritage sites.

**Method:** This article used a qualitative descriptive method with data collection techniques through library research with an empirical study approach.

**Results:** There are 10 attributes in the ecological dimension and 8 attributes in the socio-cultural dimension that are assessed for sustainable healthy settlements on Penyengat Island but some of them not eligible (facilities and infrastructure, clean water supply, household waste, occupancy density and government program to reallocate existing population settlements on cultural heritage sites).

**Conclusion:** The concept of sustainable healthy settlements in terms of socio-cultural dimensions on Penyengat Island is the harmonization between aspects of healthy settlements in terms of ecological dimensions and cultural values that are still preserved on Penyengat Island.

**Keywords:** Healthy settlement, Sustainable, Social, Cultural

## 1. Introduction

Penyengat Island is a small island that is exotic and very thick with Malay history where its size is approximately 4 km<sup>2</sup>. This island is about 2 km from the city of Tanjung Pinang which is the administrative center of the Kepulauan Riau Province. Penyengat Island is designated as a cultural heritage because it has two strategic values in the history of Indonesia. First, Penyengat Island was the stronghold of Raja Haji Fisabilillah during the war against the Dutch (1782-1784). Second, Penyengat Island is the center of Malay civilization which is rich in culture, one of which is a book by Raja Ali Haji entitled *Bustan Al-Katibin* (Malay grammar

book) which is the source of the development of Indonesian works and others including “*Gurindam Dua Belas*” who contributed to the development of Malay literature and Indonesian literature [1].

Management of cultural heritage is the responsibility of the government and the community. The government facilitates everything related to its preservation by enacting Law Number 11 of 2010 concerning Cultural Conservation. Preservation of cultural heritage as regulated in the law contains the meaning: a dynamic effort to maintain the existence of cultural heritage and its value by protecting, developing, and utilizing it [2].

The Penyengat Island Cultural Conservation

---

\* Corresponding author.

E-mail address: indramartias@gmail.com (Indra Martias)

Area has carried out conservation activities in the form of protection, development, and utilization by the government. With the commencement of the conservation activities, it is necessary to study the conservation planning in each complete zoning accompanied by the rules governing such as in the core, buffer, and development and/or supporting areas.

Penyengat Island itself is one of the tourist attractions in the Kepulauan Riau Province which contains various historical relics such as the Tomb of the Kings, the Grand Mosque of Sultan Riau made of egg whites, the Tomb of the national hero Raja Ali Haji, The Keraton Complex, and The Fortress in Bukit Kursi. The results of research conducted by Prayuda et al. [3] show that tourism development in Penyengat Island must implement several tourism development strategies, namely; 1) Facilitative Strategy, 2) Educational Strategy, 3) Power Strategy and 4) Persuasive Strategy. In addition, the development of information system-based tourism can be an option for the community to promote Penyengat Island, which is unique in terms of historical aspects. All of the above strategies must be followed by strengthening resource capacity in the field of tourism management, increasing public awareness of the potential of the surrounding environment, and government regulations or policies that can accelerate tourism development on Penyengat Island.

Research conducted by Rijal stated that the growth of coastal settlements on Penyengat Island was divided into six growth phases, namely: Phase I, as a Defense Island; Phase II, as Raja Island; Phase III, as Love Island; Phase IV as Sultan Island; Phase V, as Heritage Island; and Phase VI, as a Heritage Island. The spatial phenomenon of coastal settlements on Penyengat Island is a typical settlement with traditional Malay values and is unique in its growth process. This is related to past events related to the civilization of the Malay kingdom in the Malay Peninsula, especially the Riau Lingga Malay Kingdom [4].

Research by Ramelan et al. shows that the settlements and residences of the people of

Penyengat Island are very close to the existing cultural heritage sites, but now people are building houses on the remaining footprints of the buildings from the cultural heritage on the grounds that they do not want to leave Penyengat Island because they have lived on the land for generations [5].

The coastal area of Penyengat Island, which is a tourist destination, certainly has quite dense activities such as ecotourism areas, marine transportation activities, construction of tourist parks, and temporary shelters for garbage and household activities that throw waste into the waters. Community activities around the coast of the island have contributed to the decline in water quality [6].

Various problems that exist in Penyengat Island, especially those related to the health of residential areas and the preservation of cultural heritage, of course, require comprehensive handling. Penyengat Island, which has become an international historical tourist destination, if the settlements are not arranged in such a way, will cause many environmental problems and ultimately reduce the health status of the community.

## **2. Objectives**

This study aimed to offer the arrangement concept of sustainable healthy settlement based on the socio-cultural life in the community so that the existence of cultural heritage sites can be maintained.

## **3. Methodology**

This study uses a qualitative descriptive research method that focuses on conditions and empirical/natural object data collected collectively with literature and documentation. The focus of this research is the arrangement of healthy settlements on Penyengat Island based on the socio-cultural life which is the local wisdom of the local community. Along with its development, Penyengat Island has become an interesting topic to formulate a model of healthy settlement arrangement based on the concept of eco-settlement which has the potential to improve people's welfare.

Table 1. Number and population density of Penyengat Island village in 2016-2020

Demographics	Year 2016	Year 2017	Year 2018	Year 2019	Year 2020
Total population (People)	2.266	2.275	2.310	2.475	2.502
Population density (People/km <sup>2</sup> )	2.041	2.050	2.112	2.175	2.197

Source: Tanjungpinang District City in Figures 2016-2020 [7].



Fig. 1. Several cultural reserves on Penyengat Island

## 4. Results and Discussion

### 4.1. Research locations and population growth

Penyengat Island is located in the administrative area of Tanjungpinang City, Republic of Indonesia. The area of Penyengat Island is 91.15 hectares. The population of Penyengat Island is 2502 people with a population density of 2197 per km<sup>2</sup> (Table 1).

### 4.2. Analysis of the importance of cultural sites

An object, building, or location if it has important values contained in it, can be submitted as an object, building, or location that is legally protected or reserved. Substantively, these important values become the criteria for objects, buildings, or locations which in this case are referred to as cultural heritage. Some objects that have been designated as cultural heritage include: 1) Three forts and one fortification 2) Ten tombs 3) Six buildings and eight building footprints 4) Three wharf sites 5) One ancient ditch 6) Twelve wells and 6) One pool/bath.

There are 2 main factors that cause the cultural heritage to not be intact anymore: 1) Historical factors, in 1911 Sultan Abdul Rahman Muazam Syah and the royal family left Penyengat Island and fled to Singapore because they were not willing to sign a contract with the Dutch which eliminated the rights and powers of the

king. 2) Development pressure and the increasing number of residents on Penyengat Island so that many residents build houses in the cultural heritage area. Fig. 1 shows the several cultural reserves on Penyengat Island.

### 4.3. The cultural identity of the people of Penyengat Island

Penyengat Island has dozens of surviving sites and its surrounded by people who are believed to be descendants of the cultural supporters who produced the material cultural heritage. The problem is whether the local community is willing to preserve and understand that the material cultural heritage can provide great benefits.

Several studies have been conducted on Penyengat Island regarding the attitude of the community towards these historical relics. Sanyi [8] in his conclusion explains that it is still necessary to socialize the importance of managing these attractions to people who are seen as apathetic. Slightly different from Sanyi [8], Haryanto [9] in his thesis shows that the existence of indigenous people who have distinctive characteristics and have an attachment to their past culture is a potential that can be used as a means to promote and preserve the culture found on Penyengat Island.

According to Muhammad Maulana, easy

transportation to various places has caused the people of Penyengat Island in general to experience a social change. These changes do not always bring progress, but there are negative changes such as the loss of ambition and solidarity in the people of Penyengat Island. This is the government's homework so that identity as a member of the culture of Penyengat Island is maintained [10].

From the results of the literature survey and discussion, it can be concluded that the attitude of the community wants clear steps regarding the management of material cultural heritage on Penyengat Island. This shows that there are still values that are considered important which will later become the basic capital in developing the cultural potential of the Penyengat Island Region.

#### *4.4. The importance of local wisdom on Penyengat Island*

Local wisdom (local wisdom, local genius) is the result of the thoughts and ideas of local people or people. The results of these thoughts and ideas are used as value guidelines by the community in most people in everyday life.

One of the strengths of local wisdom is its ability to last a long time. Its values will not be lost so that it continues to be guided by a society or nation from generation to generation. Local wisdom also can reduce the incoming foreign cultural values so that only the best things from the foreign culture are adopted. Penyengat Island has a heritage that is worth local wisdom, especially Malay local wisdom. Penyengat Island has proven itself to be able to maintain and develop the Malay characteristic, namely intellectual creativity that is truly stunning. The commitment of the present Penyengat Island community is to care for, foster, develop, and implement Malay-Islamic traditions, customs, and manners.

The entire culture on Penyengat Island cannot be separated from the history and ancestral heritage that is still preserved by the local community, including: 1) Malay customs at the wedding ceremony on Penyengat Island which begins with Merisik, Minang, Menika, Tepuk Tepung Tawar, Tite, Banquets, Youth Party

Events until the closing of the wedding party. 2) The uniqueness of Penyengat Island is the location of its language, which is Malay. Despite a lot of urbanization, Malay culture cannot just disappear. This has become one of the identities of the people of Penyengat Island which is still preserved, but also introduced and promoted abroad. 3) The art of Malay culture on Penyengat Island begins with a dance accompanied by musical instruments wrapped in regional and modern customs that add new flavors. 4) The religious system has penetrated the customary system starting from worship, death ceremonies, prayer readings, and marriages.

#### *4.5. Penyengat Island's sustainable healthy settlements*

The health of the housing and residential environment is the physical, chemical, and biological conditions in the house, in the home and residential environment, thus enabling residents to obtain an optimal degree of health. The concept of sustainable settlement arrangement / eco-settlement is a concept of harmonization between socio-cultural, economic, and ecological aspects towards ecosystem sustainability supported by a capable institutional system [11]. According to Sarbidi [12], several criteria for environmentally friendly settlements are the location of the settlements being on the right land allocation, optimizing land use, implementing zero water and zero waste, controlling air pollution, and green building code or environmentally friendly buildings.

The concept of sustainable settlements is based on the understanding of settlements which are defined as a place for human life that involves various aspects of physical, social, economic, and cultural aspects. One of the dimensions that become a benchmark for the sustainability of healthy settlements on Penyengat Island is the socio-cultural dimension. This is related to Penyengat Island as a cultural heritage that has strategic value in history in Indonesia and is at the center of Malay civilization which is rich in culture related to history that connects three countries, namely Indonesia, Malaysia, and Singapore.

Table 2. Attributes in ecological dimensions for the sustainability of healthy settlements in Penyengat Island

No	Attributes	Evaluation
1	Location	Eligible
2	Air quality	Eligible
3	Facilities and infrastructure	Not eligible
4	Disease vectors	Exist
5	Clean water supply	Not eligible
6	Household waste	Not eligible
7	Occupancy density	Not eligible
8	Lighting in the house	Eligible
9	Noise	Eligible
10	Building density	Tight

Table 3. Attributes of the socio-cultural dimension for the sustainability of healthy settlements in Penyengat Island

No	Attributes	Evaluation
1	Community involvement in social activities	Yes, less than optimal
2	Community group management	Yes, less than optimal
3	Level of education	Senior high school
4	Local wisdom preserves local culture	Exist
5	Population growth	Moderate
6	Social conflict	Yes, less than optimal
7	Public awareness of the importance of the existence of cultural heritage sites	Aware
8	A government program to reallocate existing population settlements on cultural heritage sites	Yes, not optimal

Land use on the island of Penyengat is dominated by the use of residential land in the area around the coast. Along with the increase in population, residential land is also increasing, this results in the distance between the cultural heritage site and residential areas being very close, even some residents have built housing on the former site of the existing cultural heritage site.

Traditional building styles include the shape and style of the residents' houses, which are divided into two, namely buildings on the beach generally on stilts and with platforms and buildings on land generally using pedestal and stilt foundations. The shape and style of the historic building are a blend of Middle Eastern and Malay styles.

There has been no research linking traditional residential building styles with cases of disease based on residential environments on Penyengat

Island. Upper Respiratory Tract Infection is the most common disease case on Penyengat Island as seen in the report of the Bugis Village Health Center in 2021 [13].

The concept of sustainable healthy settlements in terms of socio-cultural dimensions on Penyengat Island is the harmonization between aspects of healthy settlements in terms of ecological dimensions and cultural values that are still preserved on Penyengat Island (Table 2 and 3). Sala et al. [14] in his study, stated that researchers need to complement the role of history in identifying sustainability problems with a greater willingness to be directly involved in community development as an effort to provide practical solutions to existing problems. Sustainability is a solution-oriented discipline that studies the complex relationship between nature and humans, the reconciliation of interrelated scientific and social reference

paradigms, and covers multi-temporal and spatial scales.

## 5. Conclusion and Recommendations

Based on the findings and the existing conditions of residential settlements on Penyengat Island, it was concluded that population growth resulted in the expansion of settlements, which resulted in the distance between settlements and cultural heritage sites being very close. The concept of sustainable healthy settlements in terms of socio-cultural dimensions on Penyengat Island is the harmonization between aspects of healthy settlements in terms of ecological dimensions and cultural values that are still preserved on Pulau Penyengat. A concept of sustainable healthy settlement arrangement is needed on small islands such as Penyengat Island to create harmonization between population growth, settlements, and the preservation of cultural heritage. The goal is to improve the welfare of the community which in turn will improve the health status of the people on Penyengat Island.

## References

- [1] Tanjungpinang City Regional Regulation, concerning Management of Penyengat Island Cultural Tourism Number 8 of 2018.
- [2] Law of the Republic of Indonesia concerning Cultural Conservation Number 11 of 2010. Available from: [https://sherloc.unodc.org/cld/uploads/res/document/idn/law-11-of-2010\\_html/ind\\_act11\\_10\\_clther\\_entof.pdf](https://sherloc.unodc.org/cld/uploads/res/document/idn/law-11-of-2010_html/ind_act11_10_clther_entof.pdf)
- [3] Prayuda R, Syafrinaldi, Akbar D, Nurman, Sary DV. Development of Penyengat Island area as an international tourism area based on heritage tourism. *International Journal of Sustainable Development and Planning*. 2022; 17(4): 1367-71. doi: 10.18280/ijstdp.170434
- [4] Rijal. Growth of coastal settlements on Penyengat Island, National Seminar on "Local Wisdom in Diversity for Indonesian Development" Faculty of Engineering, University of North Sumatra; 2019.
- [5] Ramelan WDS, Oesman O, Ghautama G, Rahardjo S, Widiono P. Konsep Zonasi Pulau Penyengat: Sebuah Alternatif. *Amerta*. 2017; 35(1): 61-74. doi: 10.24832/amt.v35i1.237
- [6] Rosdatina Y, Apriadi T, Melani WR. Makrozoobentos sebagai bioindikator kualitas perairan Pulau Penyengat, Kepulauan Riau. *Jurnal Pengelolaan Lingkungan Berkelanjutan*. 2019; 3(2): 309-17. doi: 10.36813/jplb.3.2.309-317
- [7] Tanjungpinang District City in Figures 2016-2020.
- [8] Sanyi A. Community participation in management of Penyengat Island tourism object Tanjungpinang City. *Jom FISIP*. 2014; 1(2): 1-17.
- [9] Haryanto R. Community participation in preserving cultural conservation objects on Penyengat Island as an effort to preserve Malay cultural heritage. Semarang: Diponegoro University; 2005.
- [10] Maulana M. Behavioral changes in the people of Penyengat Island. Faculty of Social and Political Sciences, Raja Ali Haji Tanjungpinang Maritime University; 2015.
- [11] A'yun Q. Evaluasi Tingkat Kualitas Hidup bagi Permukiman Nelayan di Desa Pesisir Tambak Wedi dengan Kriteria Eco-Settlement. *EMARA: Indonesian Journal of Architecture*. 2017; 2(2): 69-77. doi: 10.29080/emara.v2i2.24
- [12] Sarbidi. Design criteria of the urban area sustainable drainage for human settlements. *Journal of Settlements*. 2014; 9(1).
- [13] Bugis Village Health Center. Report of the Bugis Village Health Center in Tanjungpinang City in 2021. Bugis Village Health Center; 2021.
- [14] Sala S, Ciuffo B, Nijkamp P. A systemic framework for sustainability assessment. *Ecol Econ*. 2015; 119: 314-25. doi: 10.1016/j.ecolecon.2015.09.015

# Association of Multifidus Thickness with Disability, Lumbar Stability and Kinesiophobia in Movement Control Impairment Subgroup of Chronic Low Back Pain

Soniya Maharjan, Khin Win Thu, Kanphajee Sornkaew, Sasithorn Konguon, Katayan Klahan, Peemongkon Wattananon \*

Spine Biomechanics Lab, Faculty of Physical Therapy, Mahidol University, Thailand

## Abstract

**Background:** Global burden of disease data shows low back pain as the fourth leading cause of disability. Lumbar multifidus muscle (LM) deficit is one of the underlying mechanisms for compromised spinal stability causing chronic low back pain (CLBP), particularly in the movement control impairment (MCI) subgroup. Although evidence demonstrated the association between CLBP and kinesiophobia, there is insufficient evidence regarding the roles of LM in lumbar stability, disability, and kinesiophobia. This study aimed to determine the associations between LM thickness and lumbar stability, disability level, and kinesiophobia.

**Methods:** 33 participants with CLBP during remission and having MCI were recruited. Rehabilitative ultrasound imaging was used to measure LM thickness at rest and maximum voluntary isometric contraction and was further used to calculate percent LM thickness change (%LM). An electromagnetic motion tracking system was used to measure lumbar stability at lumbar levels L<sub>4</sub> and L<sub>5</sub> during rest and leg raise positions of prone instability test. These data were used for the lumbar stability index. Thai-version Oswestry disability index and Tampa scale of kinesiophobia were used to assess disability and kinesiophobia, respectively. Spearman's rank correlation coefficient was used to assess statistical associations.

**Results:** Findings demonstrated a significant moderate positive correlation between %LM and lumbar stability index at L<sub>5</sub> ( $\rho = 0.42$ ,  $P < 0.05$ ) and a trend at L<sub>4</sub> ( $\rho = 0.32$ ,  $P = 0.08$ ), while %LM was not significantly associated with disability and kinesiophobia ( $P > 0.05$ ).

**Conclusions:** Association between %LM and lumbar stability index suggests the role of LM in providing stability to the lower lumbar spine. No significant association between %LM and disability and kinesiophobia suggests clinicians should consider LM deficit might not be key to decreasing disability and fear of movement, and additional interventions may be needed to treat this subgroup of CLBP.

**Keywords:** Multifidus, Lumbar stability, Movement control impairment, Low back pain

## 1. Introduction

Recent Global burden of disease data and Lancet series depicted low back pain (LBP) as a common global health problem with frequent recurrence up to 69% within a year [1, 2]. LBP has shown to have a significant impact on one's daily functioning, psychological aspect, and

ultimately on the nation's economy [1-3]. The majority of LBP as high as 85% are non-specific among which 30% are due to movement control impairment (MCI) [4, 5]. MCI in LBP has widely been studied in current literature and is defined as the inability to control the spine during functional tasks [5-8]. This compromised stability during

\* Corresponding author.

E-mail address: peemongkon.wat@mahidol.ac.th (Peemongkon Wattananon)

functional tasks increased the tendency of injuring the surrounding spinal structures resulting in the perpetuation of LBP into chronic low back pain (CLBP) [5, 7].

Studies have proposed Lumbar Multifidus muscle (LM) dysfunction as one of the potential underlying mechanisms for the compromised stability of the lumbar spine [9-11]. Theoretically, LM, which is responsible for two-thirds of the lumbar stability during static and dynamic tasks is found to undergo various abnormal changes in CLBP compared to healthy individuals [9-11]. In CLBP, structural and functional impairments in LM such as atrophy, fatty infiltration, stiffness, reduced thickness, and muscle activation deficit have been reported and researchers suggested these could be the reasons for the recurrence and persistence of CLBP [11-13]. Hence, specific interventions such as stabilization exercises and motor control training have been designed to improve LM function [14, 15]. Despite theories and recent intervention studies focusing on LM, it remains unclear whether LM dysfunction is associated with lumbar stability [9-11, 14, 15]. Therefore, it is necessary to investigate the association between LM function and lumbar stability.

In addition, not only at the structural level but individuals with CLBP have been shown to limit their daily activities and get affected psychologically by developing a fear of movement or kinesiophobia [1]. The disability rate in CLBP has been increasing and is projected to increase in working age groups [1, 2]. Regarding the association between LM and disability, evidence showed mixed findings based on different muscle characteristics [13, 14, 16]. There was no association with LM thickness [16] while LM stiffness [13] was associated with disability. However, studies showing no association were done in a heterogeneous group of CLBP in which compromised stability due to LM dysfunction may not be the major concern like in the MCI subgroup. Furthermore, the CLBP study demonstrated kinesiophobia as a strong predictor of disability, unlike acute LBP, where kinesiophobia may resolve with the recovery of pain [17]. Studies revealed associations of

kinesiophobia with pain and abnormal trunk kinematics but with LM activity there was weak to no correlation [18-21] and, with LM thickness is still unknown although it is found to diminish in CLBP who have kinesiophobia compared to healthy individuals [16].

Considering these gaps, the purpose of this study was to determine the relationship between LM thickness and clinical outcomes (lumbar stability, disability, and kinesiophobia) in the MCI subgroup of CLBP. We hypothesized that LM thickness will be associated with lumbar stability, disability, and kinesiophobia. The outcome of this study may provide a better understanding in terms of the International Classification of Disability and functioning (ICF) by determining interactions between structural impairment (LM dysfunction), activity limitations (disability), and personal factors (kinesiophobia). This may then enable clinicians in the comprehensive and effective planning of interventions, particularly for MCI subgroup of LBP.

## 2. Methods

### 2.1. Study Design

The study used a cross-sectional design to determine the associations between LM function and outcome measures (lumbar stability, disability level, and kinesiophobia) in individuals with CLBP. Ethical approval was taken from the Mahidol University Institutional Review Board complying with the guidelines provided by the declaration of Helsinki (MU-CIRB 2021/184.0309).

### 2.2. Participants

Thirty-three participants with CLBP were recruited from the Faculty of Physical Therapy, Mahidol University, and its surrounding areas. The participants were included if: a) they were aged between 18-40 years old, b) had a history of back pain for more than 3 months, or had a recurrent pattern of back pain for at least two episodes that interfered with activities of daily living and/or required treatment and, c) 2 or more positives in movement control battery tests by Luomajoki et al. [6]. The exclusion criteria were

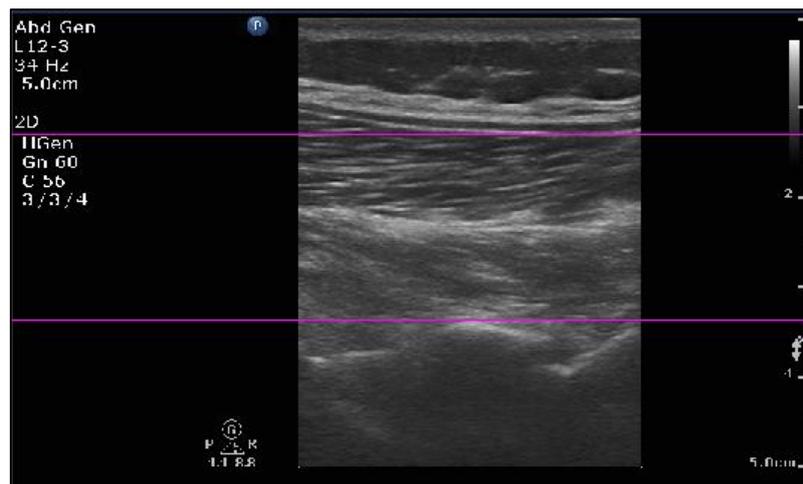


Fig. 1 Linear distance between facet joint and thoracolumbar fascia representing LM thickness

the presence of specific low back pain conditions (e.g., degenerative spine, spondylosis, or spinal stenosis), history of abdominal or back surgery, red flags (e.g., infection, tumor, fracture, radicular syndrome, or inflammatory disease), or previously diagnosed with neurological, musculoskeletal, or cardiac diseases (e.g., scoliosis, myelopathy, atrial fibrillation). We did not perform sample size calculation because this study was a part of intervention study with pre-specified sample size. All participants provided a written informed consent prior to data collection.

### 2.3. Instrumentation and Measurements

#### 2.3.1. Lumbar multifidus thickness

Rehabilitative ultrasound imaging (RUSI; model Affiniti 50, Philips, NV, USA) with a broadband linear array (model L12-3) transducer was used to measure LM thickness. The participants were placed in a prone position on a plinth stabilizing their thorax and pelvis with straps to minimize unnecessary movements. Towel was placed if required under the abdomen to maintain the spine in a neutral position. The bony landmarks, lumbar spinous processes (L<sub>1</sub> to S<sub>2</sub>), and L<sub>4</sub>-L<sub>5</sub> facet joint (2 cm lateral to lower half L<sub>4</sub> spinous process) were identified. The RUSI transducer was placed over L<sub>4</sub>-L<sub>5</sub> facet joint which is directly corresponding to the location of LM. The linear distance between facet joint and thoracolumbar fascia represents LM thickness

(Fig. 1). Our previous study using RUSI showed no significant difference in LM thickness between the sides [22]. Therefore, this study measured LM thickness on the painful side identified by palpation. For those with bilateral pain, the most painful side was chosen. If no difference in the pain on either side or multiple site tenderness, the dominant side was chosen. Two RUSI images were taken at rest ( $LM_{rest}$ ) and during maximum voluntary isometric contraction ( $LM_{MVIC}$ ) with 1 minute rest in between. For  $LM_{MVIC}$ , the participants were asked to flex their elbows to 90°, shoulder abducted to 120° of the contralateral side of the pain. The participants performed back extension with rotation towards the opposite side of pain according to LM function against maximum resistance given by the outcome assessor. Percent change in thickness was then calculated using formula;  $[(LM_{MVIC} - LM_{rest}) / LM_{rest} \times 100]$ . Excellent intra-rater reliability (ICC<sub>3,1</sub>): 0.987-0.996 and inter-rater reliability (ICC<sub>2,2</sub>): 0.978 were achieved prior to data collection.

#### 2.3.2 Lumbar stability

Electromagnetic motion tracking system (EMT; 3D Guidance trakSTAR, Ascension Technology Corp., Burlington, VT) was used to collect posterior-anterior (PA) displacement at L<sub>4</sub> and L<sub>5</sub> segments at 100 Hz. EMT has been frequently used in research to assess PA motion

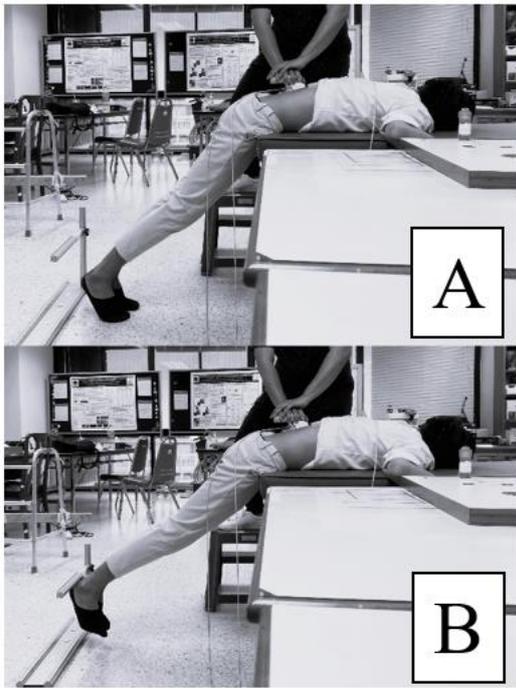


Fig. 2 Assessor applying 100N posterior-anterior compression force; A: At rest, when participant is lying prone with both legs out of the treatment table and feet on the ground; B: At leg raise, when both legs are raised to the reference bar kept at 10 inches off the ground.

of vertebral segments [23, 24]. PA displacement against applied external PA force can represent lumbar stability [25]. Three sensors were attached at T<sub>12</sub>, S<sub>2</sub>, and hand-held dynamometer (Model 01165, Lafayette Instrument, Lafayette, IN) which was used to apply PA compression force. Resolution reported by the manufacturer of EMT was 1.4 mm for positional data and 0.5 degrees for rotational data. Our pilot work showed adequate test-retest reliability of lumbar segmental displacement ( $ICC_{3,1}=0.67$ ;  $CI=0.58-0.74$ ). The participants were tested at rest and leg raise positions of prone instability test (PIT). PIT is a routinely used test in physical therapy clinics to identify individuals with CLBP with suspected clinical spinal instability [26]. At rest, participants were asked to lie in a prone position on a firm treatment table with both legs off the table and feet on the ground. The assessor used a hand-held dynamometer with an EMT sensor to apply a 100N PA compression force over the L<sub>4</sub> and L<sub>5</sub> spinous processes (Fig. 2A). Our pilot study in

5 healthy subjects demonstrated 100N PA force was well tolerable and showed linear force-displacement curve. The force was applied for 10 seconds at the end of expiration as a standardized protocol to decrease the chance of raising the intra-abdominal pressure which may affect the PA displacement. Participants were then asked to raise both legs to a reference bar set to 10 inches above the ground. A study by Wattananon et al. showed significant activity of LM when hip was extended to 10 degrees in prone position [27]. The assessor then applied the same 100N PA compression force over the spinous processes (Fig. 2B). Two trials were taken for each position with a 2-minute rest between measurements. PA displacements were measured at L<sub>4</sub> and L<sub>5</sub> segments for both rest ( $DIST_{rest}$ ) and leg raise position ( $DIST_{UP}$ ). Then stability index was calculated using formula;  $[(DIST_{rest} - DIST_{UP}) / DIST_{rest} \times 100]$ .

### 2.3.3. Disability assessment

Thai version of Oswestry disability index (ODI) was used to measure disability. Thai ODI is a self-administered questionnaire comprising questions related to activities of daily living and has demonstrated good internal consistency, 0.81 and content validity for item correlation ranging from 0.6 – 1 [28]. It consists of ten sections, each section being scored in 6-point Likert scale, 0 representing no disability and 5 representing the greatest disability. The obtained score was divided by the total possible score, which is then multiplied by 100 and expressed as a percentage. For every question not answered, the denominator is reduced by 5. Disability percentage ranging between 0-20% was interpreted as minimal disability, 21%-40% as moderate disability, 41%-60% as severe disability and 61%-80% as crippled and 81%-100% as bed-bound [29].

### 2.3.4. Kinesiophobia assessment

17-itemed self-administered questionnaire, Tampa scale of kinesiophobia (TSK) was used to assess the fear of movement. Each question is scored in 4-point Likert scale with 1 being strongly disagree and 4 being strongly agree for items 1, 2, 3-7, 9-11, 13-15, and 17 and vice versa

Table 1. Demographic characteristics

Demographic data	Mean $\pm$ SD or percentage
Age (years)	27.7 $\pm$ 6.8
Number of females (% female)	17 (51.5%)
Number of males (% male)	16 (48.5%)
Body mass index (kg/m <sup>2</sup> )	23.3 $\pm$ 4
Duration of low back pain (years)	3.5 $\pm$ 3.9
Recurrent episodes within 6 months (episodes)	9.1 $\pm$ 8.1

SD: Standard deviation

Table 2. Association between percent LM thickness change and clinical outcomes

Clinical outcomes	Median [IQR]	Percent LM thickness change (%LM)	
		Correlation coefficient ( $\rho$ )	P-value
Disability (ODI, %)	8 [4,12]	-0.11	0.54
Kinesiophobia (TSK score)	40 [35,44]	-0.12	0.56
Lumbar stability index at L <sub>4</sub>	27.1 [-3,53.6]	0.32	0.081
Lumbar stability index at L <sub>5</sub>	19.3 [-62,49.9]	0.42	0.022*
Percent LM thickness change	31.4 [24.9,39.6]	N/A	N/A

ODI: Oswestry disability index; TSK: Tampa scale of kinesiophobia; \*:  $P < 0.05$ ; IQR: Inter-quartile range; L<sub>4</sub>: 4<sup>th</sup> lumbar level; L<sub>5</sub>: 5<sup>th</sup> lumbar level

for the remaining items. The total score ranges from 17-68 and the cut-off score is 37 i.e., 17-37 indicating low and  $>37$  indicating high kinesiophobia. TSK demonstrated good internal consistency; 0.7-0.83, test-retest reliability; Pearson's correlation,  $r = 0.64-0.80$  and moderate concurrent validity; (Pearson's correlation,  $r = 0.33-0.59$  with fear avoidance behavior questionnaire) in low back pain population [30].

### 3. Results

In this study, a total of 33 (17 females and 16 males) participants with chronic non-specific low back pain were found to be eligible. The mean age of the participants was 27.7 years and mean BMI was 23.3 kg/m<sup>2</sup>. The participants had low back pain of a mean duration greater than 3.5 years with recurrent episodes more than 9 times in last 6 months. Demographic data are presented in Table 1.

Descriptive information on disability, lumbar stability and kinesiophobia and their association with percent LM thickness change (%LM) are summarized in Table 2. The participants reported minimal disability with ODI percent ranging

from 4% to 12% while low to high levels of kinesiophobia with TAMPA score ranging from 35 to 44. The results showed a significant moderate positive association of percent change in LM thickness (%LM) with lumbar stability index at L<sub>5</sub> ( $\rho = 0.42$ ,  $P < 0.05$ ) and a trend at L<sub>4</sub> ( $\rho = 0.32$ ,  $P = 0.08$ ) while there was no association with disability level and kinesiophobia ( $P > 0.05$ ).

### 4. Discussion

This study aimed to link 3 ICF domains, structural impairment with activity limitations, and personal factors by investigating an association between LM thickness and clinical outcomes (lumbar stability, disability, and kinesiophobia) in individuals with chronic low back pain (CLBP). The findings partially supported our hypothesis showing a significant positive association of LM thickness with lumbar stability but not with disability and kinesiophobia.

There are no studies demonstrating a direct relationship between LM thickness and lumbar stability; nevertheless, there is ample evidence demonstrating LM as the prime stabilizer for the

lumbar spine [11, 31, 32]. Its unique architecture of the larger physiological cross-sectional area in lower lumbar spine; particularly at L<sub>4</sub>-L<sub>5</sub> region and high concentration of muscle spindles as well as its intersegmental attachment generate greater force even at small excursions possessing a greater biomechanical advantage for lumbar stability [11, 31, 32]. Additionally, feed-forward control of LM during various tasks or perturbation and compensatory adaptation in response to atrophy and deformation of other active and passive structures makes LM a major stabilizer [33-35]. Hence, the finding of our study demonstrating an association between LM thickness and lumbar stability is in line with previous studies. However, our results showed a significant association with L<sub>5</sub> only but a trend in L<sub>4</sub>. A previous study found individuals with CLBP have significantly lower %LM at L<sub>5</sub> compared to other lumbar levels than in healthy individuals [10]. Similarly, participants in our study as well might not have prominent abnormal % LM in L<sub>4</sub> to show a statistically significant association. Even so, showing a trend and a significant association in our study is suggestive of the role of LM in stabilizing the lower lumbar spine.

Recent studies further assessed the role of LM during various static and dynamic tasks [36-39]. A study by Hemming et al found increased activity of LM in CLBP than in healthy individuals during many functional activities [37]. Another study by Dankaerts et al. also reported similar findings in sitting [36]. Those studies explained the increased activity of LM as a protective phenomenon to stabilize the spine [36, 37]. In contrast, several other studies showed decreased activity of LM in CLBP after the pain subsided during the remission phase [38-40]. A study by Rowley et al. demonstrated that decreased activity of the LM led to reduced trunk-pelvis coordination during the balance-dexterity task [38]. Likewise, Wattananon et al. and Shih et al. also had consistent results when assessed during forward-bending and walking respectively [39, 40]. Therefore, higher levels of LM activity leading to an increase in stability and lower levels of activation causing reduced

movement control is supportive of our findings of a positive correlation between LM thickness and lumbar stability.

In this study, we found minimal disability in the participants, which is the common finding in CLBP according to recent studies [1, 21, 41, 42] but disability was not associated with LM thickness. Several systematic reviews and studies using MRI and RUSI also found no relationship between LM thickness and disability [16, 43-46]. Minimal disability at baseline in this study as the participants were in remission phase could be one reason for an insignificant statistical association which is supported by Barker et al. [47]. However, another muscle characteristic such as stiffness using shear wave elastography was found to be associated with disability [13]. Thus, future studies could explore other muscle features using other technologies to determine potential associations.

The participants in our study reported low to a high level of kinesiophobia like in other studies [1, 21, 41, 48] but were not associated with LM thickness. A study by Ishak et al. also showed no association despite the methodological difference of measuring LM function [19]. Unlike these studies, a study by Christe et al. found weak correlation [18]. No association could be because measuring LM thickness in prone position in this study might not have triggered kinesiophobia. Studies revealed perturbations or movement like lifting elicited kinesiophobia causing reduced trunk movement and motor incoordination [49, 50]. Another potential explanation could be that participants in this study were in remission phase, hence minimal to no change in LM thickness was observed as opposed to the those who have moderate to high current pain intensity or experimentally induced pain [11, 39]. In line with the findings, study by Ryota et al. demonstrated task specific fear showed an association rather than subjective reporting of kinesiophobia [20].

There are some limitations in this study. The cross-sectional design of this study cannot help establishing a cause-and-effect relationship between the parameters (LM thickness, lumbar stability, disability and kinesiophobia) studied. Caution should be taken in generalizing the

findings of this study to individual with specific low back conditions and adults age greater than 40.

## 5. Conclusion

The significant relationship between LM thickness and lumbar stability warrants the importance of LM in providing stability to the lower lumbar spine. Moreover, presence of minimal disability and low to a high level of kinesiophobia in the participants despite no correlation with LM thickness may imply that interventions targeting on LM only may be insufficient.

## Recommendations

Clinicians and/or researchers should design the intervention not only addressing the structural impairment but also personal and psychosocial factor and may investigate the effectiveness of the intervention to exhibit cause and effect relationship. Additionally, future studies may consider more sensitive objective measurements of kinesiophobia and other muscle characteristics to expand the knowledge.

## Acknowledgements

This study was partially funded by National Research Council of Thailand and Mahidol University (N42A650360). We would like to thank the Faculty of Physical Therapy, Mahidol University for providing research equipment and space for data collection. We also would like to thank all participants for their contribution to the study.

## References

- [1] Hartvigsen J, Hancock MJ, Kongsted A, Louw Q, Ferreira ML, Genevay S, et al. What low back pain is and why we need to pay attention. *Lancet*. 2018; 391(10137): 2356-67. doi: 10.1016/S0140-6736(18)30480-X
- [2] Global burden of 369 diseases and injuries in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet*. 2020; 396(10258): 1204-22. doi: 10.1016/S0140-6736(20)30925-9
- [3] da Silva T, Mills K, Brown BT, Pocovi N, de Campos T, Maher C, et al. Recurrence of low back pain is common: a prospective inception cohort study. *J Physiother*. 2019; 65(3): 159-65. doi: 10.1016/j.jphys.2019.04.010
- [4] Luomajoki H. Movement control impairment as a sub-group of non-specific low back pain: evaluation of movement control test battery as a practical tool in the diagnosis of movement control impairment and treatment of this dysfunction. Kuopio: University of Eastern Finland; 2010.
- [5] O'Sullivan P. Diagnosis and classification of chronic low back pain disorders: maladaptive movement and motor control impairments as underlying mechanism. *Man Ther*. 2005; 10(4): 242-55. doi: 10.1016/j.math.2005.07.001
- [6] Luomajoki H, Kool J, de Bruin ED, Airaksinen O. Movement control tests of the low back; evaluation of the difference between patients with low back pain and healthy controls. *BMC Musculoskelet Disord*. 2008; 9: 170. doi: 10.1186/1471-2474-9-170
- [7] Sahrman S, Azevedo DC, Dillen LV. Diagnosis and treatment of movement system impairment syndromes. *Braz J Phys Ther*. 2017; 21(6): 391-9. doi: 10.1016/j.bjpt.2017.08.001
- [8] Wattananon P, Ebaugh D, Biely SA, Smith SS, Hicks GE, Silfies SP. Kinematic characterization of clinically observed aberrant movement patterns in patients with non-specific low back pain: a cross-sectional study. *BMC Musculoskelet Disord*. 2017; 18(1): 455. doi: 10.1186/s12891-017-1820-x
- [9] Hides J, Gilmore C, Stanton W, Bohlscheid E. Multifidus size and symmetry among chronic LBP and healthy asymptomatic subjects. *Man Ther*. 2008; 13(1): 43-9. doi: 10.1016/j.math.2006.07.017
- [10] Wallwork TL, Stanton WR, Freke M, Hides JA. The effect of chronic low back pain on size and contraction of the lumbar multifidus muscle. *Man Ther*. 2009; 14(5): 496-500. doi: 10.1016/j.math.2008.09.006
- [11] Hodges PW, Danneels L. Changes in structure and function of the back muscles in low back pain: different time points, observations, and mechanisms. *J Orthop Sports Phys Ther*. 2019; 49(6): 464-76. doi: 10.2519/jospt.2019.8827
- [12] Hofste A, Soer R, Groen GJ, van der Palen J, Geerdink FJB, Oosterveld FGJ, et al. Functional and morphological lumbar multifidus characteristics in subgroups with low back pain in primary care. *Musculoskelet Sci Pract*. 2021;

- 55: 102429. doi: 10.1016/j.msksp.2021.102429
- [13] Koppenhaver S, Gaffney E, Oates A, Eberle L, Young B, Hebert J, et al. Lumbar muscle stiffness is different in individuals with low back pain than asymptomatic controls and is associated with pain and disability, but not common physical examination findings. *Musculoskelet Sci Pract.* 2020; 45: 102078. doi: 10.1016/j.msksp.2019.102078
- [14] Alrwaily M, Schneider M, Sowa G, Timko M, Whitney SL, Delitto A. Stabilization exercises combined with neuromuscular electrical stimulation for patients with chronic low back pain: a randomized controlled trial. *Braz J Phys Ther.* 2019; 23(6): 506-15. doi: 10.1016/j.bjpt.2018.10.003
- [15] Songjaroen S, Sungnak P, Piriayaprasarth P, Wang HK, Laskin JJ, Wattananon P. Combined neuromuscular electrical stimulation with motor control exercise can improve lumbar multifidus activation in individuals with recurrent low back pain. *Sci Rep.* 2021; 11(1): 14815. doi: 10.1038/s41598-021-94402-2
- [16] Pinto SM, Cheung JPY, Samartzis D, Karppinen J, Zheng YP, Pang MYC, et al. Are morphometric and biomechanical characteristics of lumbar multifidus related to pain intensity or disability in people with chronic low back pain after considering psychological factors or insomnia? *Front Psychiatry.* 2022; 13: 809891. doi: 10.3389/fpsy.2022.809891
- [17] Rainville J, Smeets RJ, Bendix T, Tveito TH, Poiraudreau S, Indahl AJ. Fear-avoidance beliefs and pain avoidance in low back pain--translating research into clinical practice. *Spine J.* 2011; 11(9): 895-903. doi: 10.1016/j.spinee.2011.08.006
- [18] Christe G, Crombez G, Edd S, Opsommer E, Jolles BM, Favre J. Relationship between psychological factors and spinal motor behaviour in low back pain: a systematic review and meta-analysis. *Pain.* 2021; 162(3): 672-86. doi: 10.1097/j.pain.0000000000002065
- [19] Ishak NA, Zahari Z, Justine M. Kinesiophobia, pain, muscle functions, and functional performances among older persons with low back pain. *Pain Res Treat.* 2017; 2017: 3489617. doi: 10.1155/2017/3489617
- [20] Imai R, Imaoka M, Nakao H, Hida M, Fujii R, Shiba T, et al. Task-specific fear rather than general kinesiophobia assessment is associated with kinematic differences in chronic low back pain during lumbar flexion: a preliminary investigation. *Pain Rep.* 2022; 7(5): 1025. doi: 10.1097/PR9.0000000000001025
- [21] Luque-Suarez A, Martinez-Calderon J, Falla D. Role of kinesiophobia on pain, disability and quality of life in people suffering from chronic musculoskeletal pain: a systematic review. *Br J Sports Med.* 2019; 53(9): 554-9. doi: 10.1136/bjsports-2017-098673
- [22] Thu KW, Maharjan S, Sornkaew K, Kongoun S, Wattananon P. Multifidus muscle contractility deficit was not specific to the painful side in patients with chronic low back pain during remission: a cross-sectional study. *J Pain Res.* 2022; 15: 1457-63. doi: 10.2147/JPR.S363591
- [23] Owens EF, Jr., DeVocht JW, Gudavalli MR, Wilder DG, Meeker WC. Comparison of posteroanterior spinal stiffness measures to clinical and demographic findings at baseline in patients enrolled in a clinical study of spinal manipulation for low back pain. *J Manipulative Physiol Ther.* 2007; 30(7): 493-500. doi: 10.1016/j.jmpt.2007.07.009
- [24] Sung W, Hicks GE, Ebaugh D, Smith SS, Stackhouse S, Wattananon P, et al. Individuals with and without low back pain use different motor control strategies to achieve spinal stiffness during the prone instability test. *J Orthop Sports Phys Ther.* 2019; 49(12): 899-907. doi: 10.2519/jospt.2019.8577
- [25] Fritz JM, Erhard RE, Hagen BF. Segmental instability of the lumbar spine. *Phys Ther.* 1998; 78(8): 889-96. doi: 10.1093/ptj/78.8.889
- [26] Hicks GE, Fritz JM, Delitto A, McGill SM. Preliminary development of a clinical prediction rule for determining which patients with low back pain will respond to a stabilization exercise program. *Arch Phys Med Rehabil.* 2005; 86(9): 1753-62. doi: 10.1016/j.apmr.2005.03.033
- [27] Wattananon P, Silfies SP, Tretriluxana J, Jalayondeja W. lumbar multifidus and erector spinae muscle synergies in patients with nonspecific low back pain during prone hip extension: a cross-sectional study. *PM R.* 2019; 11(7): 694-702. doi: 10.1002/pmrj.12002
- [28] Sanjaroensuttikul N. The Oswestry low back pain disability questionnaire (version 1.0) Thai version. *J Med Assoc Thai.* 2007; 90(7): 1417-22.
- [29] Fairbank JC, Pynsent PB. The oswestry disability index. *Spine.* 2000; 25(22): 2940-52;

- discussion 52. doi: 10.1097/00007632-200011150-00017
- [30] Swinkels-Meewisse EJ, Swinkels RA, Verbeek AL, Vlaeyen JW, Oostendorp RA. Psychometric properties of the Tampa Scale for kinesiophobia and the fear-avoidance beliefs questionnaire in acute low back pain. *Man Ther.* 2003; 8(1): 29-36. doi: 10.1054/math.2002.0484
- [31] Freeman MD, Woodham MA, Woodham AW. The role of the lumbar multifidus in chronic low back pain: a review. *PM R.* 2010; 2(2): 142-6; quiz 1 p following 67. doi: 10.1016/j.pmrj.2009.11.006
- [32] Ward SR, Kim CW, Eng CM, Gottschalk LJ, Tomiya A, Garfin SR, et al. Architectural analysis and intraoperative measurements demonstrate the unique design of the multifidus muscle for lumbar spine stability. *J Bone Joint Surg Am.* 2009; 91(1): 176-85. doi: 10.2106/JBJS.G.01311
- [33] Moseley GL, Hodges PW, Gandevia SC. External perturbation of the trunk in standing humans differentially activates components of the medial back muscles. *J Physiol.* 2003; 547(Pt 2): 581-7. doi: 10.1113/jphysiol.2002.024950
- [34] Solomonow M, Zhou BH, Harris M, Lu Y, Baratta RV. The ligamento-muscular stabilizing system of the spine. *Spine.* 1998; 23(23): 2552-62. doi: 10.1097/00007632-199812010-00010
- [35] Stokes MJ, Cooper RG, Morris G, Jayson MI. Selective changes in multifidus dimensions in patients with chronic low back pain. *Eur Spine J.* 1992; 1(1): 38-42. doi: 10.1007/BF00302141
- [36] Dankaerts W, O'Sullivan P, Burnett A, Straker L. Altered patterns of superficial trunk muscle activation during sitting in nonspecific chronic low back pain patients: importance of subclassification. *Spine.* 2006; 31(17): 2017-23. doi: 10.1097/01.brs.0000228728.11076.82
- [37] Hemming R, Sheeran L, van Deursen R, Sparkes V. Investigating differences in trunk muscle activity in non-specific chronic low back pain subgroups and no-low back pain controls during functional tasks: a case-control study. *BMC Musculoskelet Disord.* 2019; 20(1): 459. doi: 10.1186/s12891-019-2843-2
- [38] Rowley KM, Smith JA, Kulig K. Reduced trunk coupling in persons with recurrent low back pain is associated with greater deep-to-superficial trunk muscle activation ratios during the balance-dexterity task. *J Orthop Sports Phys Ther.* 2019; 49(12): 887-98. doi: 10.2519/jospt.2019.8756
- [39] Shih HS, Van Dillen LR, Kutch JJ, Kulig K. Individuals with recurrent low back pain exhibit further altered frontal plane trunk control in remission than when in pain. *Clin Biomech (Bristol, Avon).* 2021; 87: 105391. doi: 10.1016/j.clinbiomech.2021.105391
- [40] Wattananon P, Sinsurin K, Somprasong S. Association between lumbopelvic motion and muscle activation in patients with non-specific low back pain during forward bending task: A cross-sectional study. *Hong Kong Physiother J.* 2020; 40(1): 29-37. doi: 10.1142/S1013702520500043
- [41] Varallo G, Scarpina F, Giusti EM, Cattivelli R, Guerrini Usubini A, Capodaglio P, et al. Does kinesiophobia mediate the relationship between pain intensity and disability in individuals with chronic low-back pain and obesity? *Brain Sci.* 2021; 11(6). doi: 10.3390/brainsci11060684
- [42] Yoshimoto T, Oka H, Fujii T, Kawamata K, Kokaze A, Koyama Y, et al. Survey on chronic disabling low back pain among care workers at nursing care facilities: a multicenter collaborative cross-sectional study. *J Pain Res.* 2019; 12: 1025-32. doi: 10.2147/JPR.S188125
- [43] Cankurtaran D, Yigman ZA, Umay E. Factors associated with paravertebral muscle cross-sectional area in patients with chronic low back pain. *Korean J Pain.* 2021; 34(4): 454-62. doi: 10.3344/kjp.2021.34.4.454
- [44] Pinto SM, Boghra SB, Macedo LG, Zheng YP, Pang MYC, Cheung JPY, et al. Does motor control exercise restore normal morphology of lumbar multifidus muscle in people with low back pain? - A Systematic Review. *J Pain Res.* 2021; 14: 2543-62. doi: 10.2147/JPR.S314971
- [45] Rezazadeh F, Taheri N, Okhravi SM, Hosseini SM. The relationship between cross-sectional area of multifidus muscle and disability index in patients with chronic non-specific low back pain. *Musculoskelet Sci Pract.* 2019; 42: 1-5. doi: 10.1016/j.msksp.2019.03.005
- [46] Zielinski KA, Henry SM, Ouellette-Morton RH, DeSarno MJ. Lumbar multifidus muscle thickness does not predict patients with low back pain who improve with trunk stabilization exercises. *Arch Phys Med Rehabil.* 2013; 94(6): 1132-8. doi: 10.1016/j.apmr.2012.12.001
- [47] Barker KL, Shamley DR, Jackson D. Changes in the cross-sectional area of multifidus and

- psoas in patients with unilateral back pain: the relationship to pain and disability. *Spine*. 2004; 29(22): E515-9. doi: 10.1097/01.brs.0000144405.11661.eb
- [48] Macias-Toronjo I, Rojas-Ocana MJ, Sanchez-Ramos JL, Garcia-Navarro EB. Pain catastrophizing, kinesiophobia and fear-avoidance in non-specific work-related low-back pain as predictors of sickness absence. *PLoS One*. 2020; 15(12): e0242994. doi: 10.1371/journal.pone.0242994
- [49] Fujii R, Imai R, Tanaka S, Morioka S. Kinematic analysis of movement impaired by generalization of fear of movement-related pain in workers with low back pain. *PLoS One*. 2021; 16(9): e0257231. doi: 10.1371/journal.pone.0257231
- [50] Karayannis NV, Smeets RJ, van den Hoorn W, Hodges PW. Fear of movement is related to trunk stiffness in low back pain. *PLoS One*. 2013; 8(6): e67779. doi: 10.1371/journal.pone.0067779

# Newly Proposed Communication Form for Pre-radiotherapy Dental Clearance of Chonburi Cancer Hospital Network in Thailand

Thanate Kamoladisai \*, Matana Pruksapong-Kettratad

Unit of Gerodontology, Faculty of Dentistry, Thammasat University, Pathumthani, Thailand

## Abstract

**Background:** Dental clearance prior to head and neck radiotherapy (RT) is a common routine to prevent osteoradionecrosis. The objectives of this study were to 1) develop a more informative RT communication form between Cancer Hospital and dentists to reflect the less extensive negative effect of new RT technique on teeth and jaw, and 2) test the adoption rate of this newly proposed form with dentists who are responsible for providing pre-radiation dental clearance.

**Methods:** The communication form was created firstly based on current referral form used by Chonburi Cancer Hospital and additional RT information from a literature review. Then, five experts working at Chonburi Cancer Hospital finalized the new form. Next, we sent an online questionnaire survey to dentists working in 32 hospitals in Chonburi, Rayong and Chacheongsao. The questionnaire included 5-Likert scales agreement on the pre-RT dental treatment plans: one guided by the traditional form and another by the newly proposed form; also, there were questions based on Roger's "model of innovation decision process" measuring adoption rate of the new device.

**Results:** The response rate of dentist was 61% (49/81 participants) from 84% of contacted hospitals (27/32 hospitals). The new form received high adoption rate (4.14±0.53 of 5). However, 16% of dentists still would like to extract more teeth out of concern of osteonecrosis risk. We also found that 65% of participants did not know the exact amount of radiation dose that would increase the ORN risk.

**Conclusion:** This was the first study in Thailand to proposal a communication form applicable to the new RT technique aiming to reduce the number of teeth extracted to improve quality of life of the head and neck cancer patients. Although this form has high adoption rate, future research is needed to monitor long-term practice as well as incidence of osteoradionecrosis.

**Keywords:** Radiotherapy, Tooth extraction, Osteoradionecrosis, Diffusion of innovation

## 1. Introduction

Ninety percent of Head and Neck Cancer (HNCa) is squamous cell carcinoma and it is commonly treated by radiotherapy (RT) [1, 2]. There are many possible complications after radiotherapy such as xerostomia, mucositis, trismus, dysphagia, and one of the most serious complications is osteoradionecrosis (ORN). A systematic review in the year 2011 [3] reported the incidence of ORN after tooth extraction as 7%.

However, modern radiotherapy technology nowadays such as Intensity-Modulated Radiotherapy (IMRT) and Volumetric Modulated Arc Therapy (VMAT), with the ability to adjust the volume of dosage and ability to form the three-dimensional shape model, can accurately project to the target lesion and reduce the toxicity of normal tissue as much as possible [4, 5]. The prevalence of ORN in patients post-IMRT was reported lower than post-conventional

\* Corresponding author.

E-mail address: thanate.kam@dome.tu.ac.th (Thanate Kamoladisai)

This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>)

radiotherapy [6, 7]. The systematic review and meta-analysis in the year 2022 [8] calculated the pooled risk ratio & odds ratio for ORN development between pre-IMRT extraction and post-IMRT extraction were 0.18 ( $p = 0.031$ ) and 0.16 ( $p = 0.049$ ) respectively.

Pre-radiotherapy (Pre-RT) oral assessment is a common routine. Pre-RT tooth extraction is suggested for preventing ORN, but this in turn can possibly reduce the patients' quality of life [9, 10]. A qualitative study in 2018 [9] concluded pre-RT tooth extraction had a profound negative impact to HNCa patients' quality of life (QoL). They also felt that they lack information or misinformation before tooth extraction from the oncology team. Similar to the study in 2016 [10]; more than 8 teeth extracted pre-RT has been reported to significantly reduce the patients' quality of life (QoL).

The goal of this research is to balance quality of life of head & neck cancer patients and ORN prevention because modern technology of RT has already been available in Thailand. The objectives of this study were to 1) develop a more informative RT communication form between Cancer Hospital and dentists to reflect the less extensive negative effect of new RT technique on teeth and jaw, and 2) test the adoption rate of this newly proposed form with dentists who are responsible for providing pre-radiation dental clearance.

In the context of Thailand Public Health System, there are 13 regional health service areas. Each regional area constitutes of at least one tertiary hospital and multiple community hospital to form a network for referral. Radiotherapy is one of the high-cost services which would be provided at the Centre Hospital or Cancer hospital of each regional health service area. It is common that public health dentists working in community hospitals communicate with the radiation oncologists or the dentists working at the Cancer/Centre hospital to come up with proper dental treatment plan prior to RT. This study focused on the 6<sup>th</sup> Regional Health Service Network of Thailand which comprises of the Ministry of Public Health (MoPH) hospitals in

Chonburi, Rayong, Chachoengsao, Chanthaburi, Trat, Sakaeo, Prachinburi and Samutprakarn Provinces. The first RT service fully operated for this regional area was at Chonburi Cancer Hospital (CCH). However, there are also another newly operated RT services in Prapokklao Hospital in Chantaburi Province which supports the patients from Chantaburi, Trat and Sakaeo provinces. Also, patients living in Prachinburi province have normally been referred to Maharat Nakhon Ratchasima Hospital; and the patients living in Samutprakarn province is normally be referred to Rajavithi Hospital in Bangkok. Therefore, Chonburi Cancer Hospital now provides RT for the patients living only from Chonburi, Rayong and Chachoengsao provinces.

Studies globally illustrated that dentists know very well the basic knowledge about ORN [11, 12]. However, dentists who feel confident for post-RT tooth extraction was a minority [13]. In Thailand, there has been no study about the knowledge and confidence of dentist regarding prevention and management of ORN. Dentists working in community hospitals within this hospital network would receive a referral form written mostly by a dentist of Chonburi Cancer Hospital. The referral forms come with a designated dental treatment plan including specific tooth number to extract. However, the information about the patient, and the cancer treatment including RT details has been very limited. Dentists working in community hospitals may feel unease to simply follow the prescription stated in the referral form, especially when it is not in accordance to the patients' preference. However, the dentists working at community hospitals may lack several information to help guide their clinical reasoning when the dilemma occurs.

## 2. Methods

This study employed two phases: 1) The development of a new pre-radiotherapy communication form and 2) Questionnaire survey for the adoption rate of this newly proposed form among the dentists responsible for dental clearance of RT patients.

### 2.1. Study setting

The setting in phase I was at Chonburi Cancer Hospital and the setting in phase II was all MoPH hospitals in 3 provinces which were part of the Chonburi Cancer Hospital Network. Twelve hospitals in Chonburi consist of 1 tertiary (provincial) hospital, 1 general hospital and 10 community hospitals. Nine hospitals in Rayong consist of 1 tertiary (provincial) hospital, 2 general hospitals and 6 community hospitals. and 11 hospitals in Chacheongsao consist of 1 tertiary (provincial) hospital and 10 community hospitals. Total was 32 hospitals consist of 3 tertiary hospitals, 3 general hospitals and 26 community hospitals.

### 2.2. Population and samples

The numbers of dentists working in MoPH Hospitals from Chonburi, Rayong and Chachoengsao were 69, 49, and 65, respectively. Therefore, the maximum possible number of total population was 183. However, the limitation of this study was that we did not request each hospital to report the confirmed number of dentists who had seen patients for pre-RT dental clearance. Therefore, we were unable to know for certain the true number of population of interest. Instead, we employed a census approach and sent out online questionnaire to all the 183 dentists with an information sheet specifying that inclusion criteria was: “all dentists working in Chonburi, Rayong and Chachoengsao MoPH hospitals who are responsible for pre-RT dental assessment.” We first sent a letter of initial contact to the dental officer of the Provincial Public Health Offices of Chonburi, Rayong and Chacheongsao, explaining the details of the study. Then, we were approved to be added into the Line® Group Contact where kindly requested permission for personal Line® contacts of heads of dental departments of all hospitals in their provinces. Next, we sent the link of online questionnaire to head of dental departments of all hospitals in the provinces.

#### *Phase I: Pre-RT communication form development*

The initial version of pre-RT communication form was developed by adapting the previously

available referral form. The information about cancer diagnosis, cancer treatment plan, clinical oral findings, and dental treatment plan were the same content as the original referral form. The additional information incorporated into the new form was mostly about RT information (intent, dose, type and duration of RT and ORN risked area marking with colour); which was gathered from a literature review: mainly from Studer et al. [14] and Allard et al. [15]. Then, 5 clinical experts (1 Radiation Oncologist, 2 ENT Surgeons and 2 dentists) working in Chonburi Cancer Hospital finalized the form to suit the local context. The final version of the newly proposed pre-RT communication form was in Fig. 1.

#### *Phase II: Questionnaire survey*

The online version of the questionnaire was created and operated by SurveyMonkey®. This questionnaire was Thai version which developed and tested the validity with “Index of Item-Objective Congruence (IOC)” by 3 experts consisted of 2 Oral & Maxillofacial Surgeons working in academic institutions and 1 dentist working in cancer hospital. The questionnaire comprises of 3 parts. First, demographic information of the participants. Second, a five-Likert-scale questionnaire asking about participants’ agreement to the dental treatment plan based on the old and the new communication form. Third, a five-Likert-scale questionnaire measuring the adoption rate of this newly proposed communication form based on Rogers’ model of innovation-decision process [16]. The third part allowed participants to assess 5 following attributes: “Relative advantage, Compatibility, Complexity, Trialability and Observability” of the newly proposed communication form [12].

### 2.3. Data collection process

After sending the hyperlink of SurveyMonkey® online questionnaire to the head of dental department, they forwarded this link to all potential dentists in the department they see fit for this study. To increase the response rate, we sent the 2<sup>nd</sup> and 3<sup>rd</sup> reminders to the department head who act as gate keepers at 4 and 8 weeks.

The image shows two pages of a pre-radiotherapy communication form. The left page includes the following sections:
 

- Header: Logo of Thammasat University and contact information (300 M.2, 2nd Floor, 20000, Tel: 038-455632-6, Fax: 038-455066).
- Title: ใบส่งตัวผู้ป่วยเพื่อตรวจรักษาทางทันตกรรมก่อนการฉายรังสี (Patient Transfer Form for Dental Examination Before Radiation Therapy).
- Section 1: ข้อมูลผู้ป่วย (Patient Information) - Name, Age, Hospital, Referral, and Side/Stage.
- Section 2: แผนการรักษาเบื้องต้น (Initial Treatment Plan) - Surgery, Radiotherapy, Chemotherapy, Bisphosphonate.
- Section 3: ข้อมูลรังสีรักษา (Radiotherapy Information) - Intent (Curative/Palliative), Type of Radiotherapy, Dose, and Frequency.
- Section 4: ระบุว่าระดับความรุนแรงของรังสีรักษา (Specify the severity level of radiation therapy) - Includes diagrams of the head and neck with labels R and L, and two levels: Mild (Mild - ความรุนแรงรังสีรักษา <math>< 55 \text{ Gy}</math>) and Severe (Severe - ความรุนแรงรังสีรักษา <math>< 55 \text{ Gy}</math>).
- Section 5: ข้อควรระวังสำคัญ (Important Warnings) - Risk of airway obstruction, Risk of infection, Risk of bleeding, and Others.
- Section 6: ผลการตรวจในช่องปาก (Oral Examination Results) - Oral hygiene (Good, Fair, Poor) and Periodontal status (Normal, Gingivitis, Periodontitis).

 The right page includes:
 

- Section 7: แบบนำการยินยอมก่อนการฉายรังสี (Pre-radiation consent form) - Consent to treatment, consent to use of data, and other terms.
- Section 8: ข้อมูลแสดงความเป็นมิตร (Friendly information) - Name, Title, and Date.
- Section 9: สำหรับทันตแพทย์ (For the dentist) - A statement of understanding and agreement, and a signature line.

Fig. 1. Newly proposed pre-radiotherapy communication form

2.4. Data analysis

Data from the online survey was analysed using SPSS version 25 including descriptive statistics about demographic data and current situations; mean different scores regarding agreement to the dental treatment plans of the old and the new communication forms. This data was analysed using “paired t-test” or “Wilcoxon Signed Rank Test” in case of parametric or non-parametric statistics respectively. The results of the adoption rate of this new form were modified and shown in table in 3 steps (“Negative” = strongly disagree or agree, “Neutral” = neutral and “Positive” = agree or strongly agree) for a clear picture of their attitude for this new form. And mean of adoption rate can be interpreted as: “1.00-1.80 = strongly disagree”, “1.81-2.60 = disagree”, “2.61-3.40 = neutral”, “3.41-4.20 = agree” and “4.21-5.00 = strongly agree”.

2.5. Ethical considerations

This study protocol was approved by

The Human Research Ethics Committee of Thammasat University No.3; Research Project No.117/2020.

3. Results

3.1. Respondents

We found that the top 4 groups of respondents include 1) dentists with post-graduated (PG) training of oral & maxillofacial surgery, 2) dentists with post-graduated training of general dentistry, 3) dentists with post-graduated training of periodontology and 4) general dentists with no PG training. We decided to scope down the populations to include only these 4 specialties and excluded samples from specialties that there was only 1 respondent for each group such as prosthodontics (PG), orthodontics (residency), pedodontics (MSc.) and operative dentistry (PG). The response rate of individual dentists was 61% (49 from 81 dentists) and the response rate of hospital contact was 84% (27 from 32 hospitals). The characteristic of respondents was in Table 1.

Table 1. Characteristics of respondents.

Characteristic	n = 49	Percent
<b>Age (mean ± SD)</b>	36.08 ± 6.24	
<b>Gender</b>		
Male	9	18.37
Female	40	81.63
<b>Workplace Province</b>		
Chonburi	18	36.73
Rayong	14	28.57
Chacheongsao	17	34.69
<b>Working experience</b>		
< 3 years	1	2.04
3 – 5 years	10	20.41
6 – 10 years	18	36.73
> 10 years	20	40.82
<b>Post-graduation Training</b>		
Oral & Maxillofacial Surgery – Residency	4	8.16
Oral & Maxillofacial Surgery – PG	15	30.61
General Dentistry – Residency	3	6.12
General Dentistry – PG	6	12.24
Periodontology – Residency	3	6.12
Periodontology – PG	2	4.08
No Post-graduation training	16	32.65

Table 2. Concern of ORN and pre-RT dental treatment plan in current referral form

Questions	The least n (%)	Low n (%)	Neutral n (%)	High n (%)	The most n (%)
1. Are they concern about post-RT complication especially ORN?	0 (0)	0 (0)	14 (28.57)	19 (38.78)	16 (32.65)
2. Are their treatment plan follow through the plan from current referral form?	0 (0)	0 (0)	0 (0)	18 (36.73)	31 (63.27)
3. Are they agree with treatment plan from current referral form?	1 (2.04)	14 (28.57)	6 (12.24)	24 (48.98)	4 (8.16)

### 3.2. Current situation

Most dentists (44 from 49 respondents, 90%) received 1-2 patients for pre-RT dental treatment plan. Furthermore, most dentists (45 from 49 respondents, 92%) always or usually received the referral form from Chonburi Cancer Hospital. So, it was confirmed that the current referral form had been the main device of all hospitals in 3 provinces.

### 3.3. The concern of ORN

The results showed all respondents concerned about post-RT complications especially ORN risk. No one feel “the least” or “low” concerned about ORN. Furthermore, 71% (35 of 49 dentists)

showed “high” or “The most” concern (Table 2). One of the interesting findings was only 35% (17 of 49 dentists) know the exact RT dose that likely cause ORN.

### 3.4. The Current referral form (The old form) versus The Newly Proposed Communication Form

Almost half of the participants (43%, 21/49) did not fully agree with the treatment plans proposed on the old communication form (Table 2). Nearly 40% (19 of 49 dentists) wanted more information in this form. The top 2 topics they wanted were about 1) RT information and 2) each tooth diagnosis and prognosis (Fig. 2).

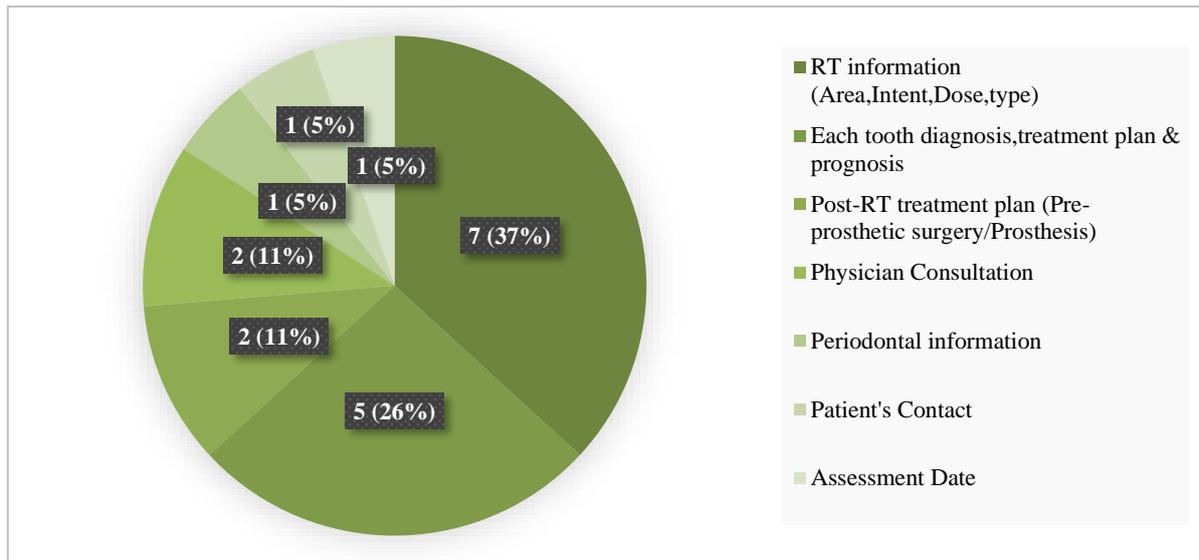


Fig. 2. What information did they want more to be in this form? [N=19]

Table 3. Current referral form VS newly proposed pre-RT communication form

Do you agree with Pre-RT dental treatment Plan?	Current Referral Form	Newly Proposed Pre-RT Communication Form	Wilcoxon Signed Rank (p-value)
Interpretation	Neutral	Agree	
Mean (SD)	3.33 (1.05)	3.84 (1.12)	
Median	4.00	4.00	0.003*

Note: \*p-value < 0.05, if statistically significant at  $\alpha = 0.05$

When asked if the dentists agreed with a dental treatment plan using information given in a current form versus a newly and more informative proposed form, the responses were neither normally distributed. On average, the median was 4.0 for both responses, with mean rank score of 13.70 for use of current form and 14.07 for the newly proposed form. The Wilcoxon Signed Rank Test indicated that the difference was statistically significant (Table 3).  $T = 309.50$ ,  $z = -2.98$ ,  $p = 0.003$ . Although the majority agree with new dental treatment plan. However, the minority which was 8 respondents (16%) wanted to extract more molars for preventing post-RT ORN.

### 3.5. The Adoption Rate of The Newly Proposed Pre-RT Communication Form

The average adoption rate of the newly

proposed pre-RT communication form is  $4.14 \pm 0.53$  and interpretation as “High” adoption rate. The adoption rate of each question was shown in Table 4.

### 4. Discussion

We created a communication tool to be used among the dentists and other tumor conference team in this network. This study showed high acceptance for this newly proposed form. However, even with high adoption rate, there were still major concerns about post-RT complications especially ORN.

In general, dentists working at community hospitals do not have a chance to communicate directly with the radiation oncologist of Chonburi Cancer Hospital. This study provided key device for communication channel that did not previously exist. The situation is similar in

Table 4. The adoption rate of the newly proposed Pre-RT Communication Form

Questions	Negative+ n (%)	Neutral++ n (%)	Positive+++ n (%)	Mean (SD)	Interpretation
<b>Relative Advantage</b>					
1. When you receive more RT information about intent (Curative/Palliative), you are more confident in Pre-RT dental treatment.	0 (0)	3 (6.12)	46 (93.88)	4.31 (0.58)	Totally Agree
2. When you receive more RT information about area and dose, you are more confident in Pre-RT dental treatment.	1 (2.04)	2 (4.08)	46 (93.88)	4.30 (0.65)	Totally Agree
3. When you receive more RT information about type (IMRT/Other), you are more confident in Pre-RT dental treatment.	2 (4.08)	9 (18.37)	38 (77.55)	4.02 (0.80)	Agree
<b>Compatibility</b>					
4. This Communication Form is compatible with the context of your hospital.	1 (2.04)	1 (2.04)	47 (95.92)	4.24 (0.60)	Totally Agree
5. This Communication Form is compatible with your knowledge, experience and idea of Pre-RT dental treatment.	1 (2.04)	2 (4.08)	46 (93.88)	4.22 (0.62)	Totally Agree
<b>Complexity</b>					
6. This Communication Form has not too much information.	2 (4.08)	3 (6.12)	44 (89.80)	4.10 (0.68)	Agree
7. This Communication Form is easy to use.	1 (2.04)	2 (4.08)	46 (93.88)	4.20 (0.61)	Agree
<b>Observability</b>					
8. This Communication Form can make more clearly Pre-RT dental treatment plan.	1 (2.04)	2 (4.08)	46 (93.88)	4.31 (0.65)	Totally Agree
<b>Triability</b>					
9. This Communication Form will not increase ORN risk	3 (6.12)	11 (22.45)	35 (71.43)	3.78 (0.74)	Agree
10. This Communication Form will decrease the unnecessarily tooth extraction.	2 (4.08)	8 (16.33)	39 (79.59)	4.00 (0.76)	Agree
11. This Communication Form can increase the post-RT quality of life.	1 (2.04)	6 (12.24)	42 (85.71)	4.10 (0.68)	Agree
<b>Mean Adoption Rate</b>					
				4.14 (0.53)	Agree

Note +Negative = totally disagree or disagree, ++Neutral = Neutral, +++Positive = agree or totally agree

many regional cancer networks in Thailand and also similar to study in Michigan, USA reported by Patel et al. [17]: i.e. “there is a major lack of communication between physicians and dentists, and dentists are not often made part of the medical team for the patient’s cancer treatment”. The strength of this newly proposed pre-RT communication form was that it was co-designed among radiation oncologist, ENT Surgeons and dentists. This newly proposed form with high acceptance from the network dentists could potentially improve the communication between dentists and other disciplines in this network. Furthermore, this form has an open-ended comment section. The dentists from community hospitals would have more channels to communicate with other disciplines from cancer hospitals.

Next, we speculate that the high concerns about post-RT complications especially ORN despite high acceptance of the new communication form was due to their lack of knowledge and confidence for new practice approach. The results showed that 32 participants (65%) did not know the exactly amount of radiation dose that can cause ORN risk even though Dewan et al. [18] reported in 2014 that anatomical site and dose of RT was the major factor for the dentist to make decision whether to extract/not-extract tooth in irradiated bone. In our study, 76% of the dentists who know the exact dose (13 of 17 participants) were the dentists that post-graduated from “Oral and Maxillofacial Surgery” or “Advanced General Dentistry”. These results corresponded with the study by Alpöz et al. [11] and Güneri et al. [12]. Participants (dental students, general dentists and specialists know very well in basic knowledge about complications of cancer therapy (88.3% – 98.7% of correct answer). However, Patel et al. [17] showed 55% of respondents feel inadequately trained in dental school to treat HNCa patients. Similar to Husein et al. [13]; only 28% was willing to perform post-RT extraction.

Interestingly, there was a study done in Thailand by Koosrivinij et al. in 2022 [19] arguing that dentists could make decision about pre-RT dental clearance with basic RT information without details from RT oncologist.

A retrospective study reviewed 13 HNCa patients at King Chulalongkorn Memorial Hospital about the area of dose distribution. They illustrated the dose distribution of teeth in 3 colours according to 8 types of HNCa and RT dose (<50 Gy, ≥50 Gy, and ≥ 60 Gy). However, there are still questions about the representativeness of varieties of types and stages of HNCa. We argue that with Koosrivinij et al.’s study in combination with the RT information provided in our newly proposed communication form may yield more precise information of each patient and bring about better clinical decision making.

Although Chonburi Cancer Hospital has the modern RT technique, but the results still showed major concern about post-RT ORN risk. Many studies showed ORN incidence was decreased after modern RT technique (IMRT) era. Moon et al. [20] stated that mandibular ORN has declined from about 20% several decades ago to 4-8% in modern series. For preventing ORN risk some participants (16%) want to extract more molar teeth in new treatment plan. While many studies such as Aarup-Kristensen et al. [21], Beech et al. [22] or Gomez et al. [23] showed no correlation about post-RT extraction and ORN incidence when using IMRT technique. And the systematic review & meta-analysis in 2022 [8] was concluded that dental extraction before IMRT compared to after IMRT have not proven to reduce the incidence of ORN.

#### 4.1. Limitation of this study

The current patient pathway of Chonburi Cancer Hospital requires HNCa patients to be referred back to their community hospitals for Pre-RT dental treatment before they get to see a radiation oncologist. If we were to implement this form in Chonburi Cancer Hospital, we still need to rearrange the workflow or patient pathway. Radiation Oncologist should be the person who marked the radiation colour in this form prior sending the form out to community hospitals. A weekly interdisciplinary tumor team case conference prior sending patients out for a dental clearance would be ideal.

The limitation of this study is the context based scenario. The findings should be interpreted

with caution and could be applied to other hospitals with similar characteristics only.

## 5. Conclusion

This newly proposed pre-RT communication form provided more RT details which co-designed between interdisciplinary tumor team working at Chonburi Cancer Hospital. Although this newly proposed Pre-RT Communication Form has high adoption rate (4.14±0.53 out of 5), there was the major concern about post-RT complication especially ORN while only 35% participants know the exact RT dose that can cause ORN.

## Recommendations

The results showed that this form was useful for communication among the dentists and other health disciplines. This newly proposed form could be launched in this network or other similar characteristic networks. Communication among the dentists about the low incidence of ORN in the recent years may help them to make more confident in Pre-RT dental treatment. Nowadays, there is still no study about the association of ORN incidence & RT dose & technique of RT & dental extraction in Thailand. Day-to-day formal clinical record keeping should be encouraged so research from clinical data registries could be done to reveal the statistics in Thailand.

## Conflict of interest

There is no conflict of interest

## Acknowledgement

We are grateful to 5 experts working in Chonburi Cancer Hospital. Radiation Oncologist; Dr. Kittisak Chomprasert 2 ENT Surgeons; Dr. Adit Chotipanich and Dr. Sombat Wongmanee, 2 dentists; Dr. On-Ong Mungkung and Dr. Orapin Chokechaitam. All of them gave very useful suggestion to develop pre-RT Communication Form. And all of respondents who gave the support of the questionnaire in this study.

## Referenc

- [1] Jawad H, Hodson NA, Nixon PJ. A review of dental treatment of head and neck cancer

patients, before, during and after radiotherapy: part 1. *Br Dent J.* 2015; 218(2): 65-8. doi: 10.1038/sj.bdj.2015.28

- [2] Beech N, Robinson S, Porceddu S, Batstone M. Dental management of patients irradiated for head and neck cancer. *Aust Dent J.* 2014; 59(1): 20-8. doi: 10.1111/adj.12134
- [3] Nabil S, Samman N. Incidence and prevention of osteoradionecrosis after dental extraction in irradiated patients: a systematic review. *Int J Oral Maxillofac Surg.* 2011; 40(3): 229-43. doi: 10.1016/j.ijom.2010.10.005
- [4] O'Sullivan B, Rumble RB, Warde P, Members of the IIEP. Intensity-modulated radiotherapy in the treatment of head and neck cancer. *Clin Oncol (R Coll Radiol).* 2012; 24(7): 474-87. doi: 10.1016/j.clon.2012.05.006
- [5] Gregoire V, Evans M, Le QT, Bourhis J, Budach V, Chen A, et al. Delineation of the primary tumour Clinical Target Volumes (CTV-P) in laryngeal, hypopharyngeal, oropharyngeal and oral cavity squamous cell carcinoma: AIRO, CACA, DAHANCA, EORTC, GEORCC, GORTEC, HKNPCSG, HNCIG, IAG-KHT, LPRHHT, NCIC CTG, NCRI, NRG Oncology, PHNS, SBRT, SOMERA, SRO, SSHNO, TROG consensus guidelines. *Radiother Oncol.* 2018; 126(1): 3-24. doi: 10.1016/j.radonc.2017.10.016
- [6] Strojan P, Hutcheson KA, Eisbruch A, Beitler JJ, Langendijk JA, Lee AWM, et al. Treatment of late sequelae after radiotherapy for head and neck cancer. *Cancer Treat Rev.* 2017; 59: 79-92. doi: 10.1016/j.ctrv.2017.07.003
- [7] Owosho AA, Tsai CJ, Lee RS, Freymiller H, Kadempour A, Varthis S, et al. The prevalence and risk factors associated with osteoradionecrosis of the jaw in oral and oropharyngeal cancer patients treated with intensity-modulated radiation therapy (IMRT): The Memorial Sloan Kettering Cancer Center experience. *Oral Oncol.* 2017; 64: 44-51. doi: 10.1016/j.oraloncology.2016.11.015
- [8] Balermipas P, van Timmeren JE, Knierim DJ, Guckenberger M, Ciernik IF. Dental extraction, intensity-modulated radiotherapy of head and neck cancer, and osteoradionecrosis : A systematic review and meta-analysis. *Strahlenther Onkol.* 2022; 198(3): 219-28. doi: 10.1007/s00066-021-01896-w
- [9] Clough S, Burke M, Daly B, Scambler S. The impact of pre-radiotherapy dental extractions

- on head and neck cancer patients: a qualitative study. *Br Dent J.* 2018; 225(1): 28-32. doi: 10.1038/sj.bdj.2018.442
- [10] Beech N, Porceddu S, Batstone MD. Preradiotherapy dental extractions and health-related quality of life. *Oral Surg Oral Med Oral Pathol Oral Radiol.* 2016; 122(6): 672-9. doi: 10.1016/j.oooo.2016.07.020
- [11] Alpoz E, Guneri P, Epstein JB, Cankaya H, Osmic D, Boyacioglu H. Dental students' knowledge of characteristics and management of oral complications of cancer therapy. *Support Care Cancer.* 2013; 21(10): 2793-8. doi: 10.1007/s00520-013-1856-x
- [12] Guneri P, Cankaya H, Kaya A, Boyacioglu H. Turkish dentists' knowledge of head and neck cancer therapy-related complications: implications for the future. *Eur J Cancer Care (Engl).* 2008; 17(1): 84-92. doi: 10.1111/j.1365-2354.2007.00813.x
- [13] Husein AB, Butterworth CJ, Ranka MS, Kwasnicki A, Rogers SN. A survey of general dental practitioners in the North West of England concerning the dental care of patients following head and neck radiotherapy. *Prim Dent Care.* 2011; 18(2): 59-65. doi: 10.1308/135576111795162910
- [14] Studer G, Glanzmann C, Studer SP, Gratz KW, Bredell M, Locher M, et al. Risk-adapted dental care prior to intensity-modulated radiotherapy (IMRT). *Schweiz Monatsschr Zahnmed.* 2011; 121(3): 216-29.
- [15] Allard WF, el-Akkad S, Chatmas JC. Obtaining pre-radiation therapy dental clearance. *J Am Dent Assoc.* 1993; 124(6): 88-91. doi: 10.14219/jada.archive.1993.0146
- [16] Rogers EM. *Diffusion of innovations.* 3<sup>rd</sup> ed. New York: The free Press; 1995.
- [17] Patel Y, Bahlhorn H, Zafar S, Zwetchkenbaum S, Eisbruch A, Murdoch-Kinch CA. Survey of Michigan dentists and radiation oncologists on oral care of patients undergoing head and neck radiation therapy. *J Mich Dent Assoc.* 2012; 94(7): 34-45.
- [18] Dewan K, Kelly RD, Bardsley P. A national survey of consultants, specialists and specialist registrars in restorative dentistry for the assessment and treatment planning of oral cancer patients. *Br Dent J.* 2014; 216(12): E27. doi: 10.1038/sj.bdj.2014.544
- [19] Koosrivinij S, Boonroung T, Prayongrat A. A retrospective observational study of high radiation dose distribution related to the tooth-bearing area in various subsites of Head and Neck cancer patients. *Journal of Thai Association of Radiation Oncology.* 2022; 28(1): R35-53.
- [20] Moon DH, Moon SH, Wang K, Weissler MC, Hackman TG, Zanation AM, et al. Incidence of, and risk factors for, mandibular osteoradionecrosis in patients with oral cavity and oropharynx cancers. *Oral Oncol.* 2017; 72: 98-103. doi: 10.1016/j.oraloncology.2017.07.014
- [21] Aarup-Kristensen S, Hansen CR, Forner L, Brink C, Eriksen JG, Johansen J. Osteoradionecrosis of the mandible after radiotherapy for head and neck cancer: risk factors and dose-volume correlations. *Acta Oncol.* 2019; 58(10): 1373-7. doi: 10.1080/0284186X.2019.1643037
- [22] Beech NM, Porceddu S, Batstone MD. Radiotherapy-associated dental extractions and osteoradionecrosis. *Head Neck.* 2017; 39(1): 128-32. doi: 10.1002/hed.24553
- [23] Gomez DR, Estilo CL, Wolden SL, Zelefsky MJ, Kraus DH, Wong RJ, et al. Correlation of osteoradionecrosis and dental events with dosimetric parameters in intensity-modulated radiation therapy for head-and-neck cancer. *Int J Radiat Oncol Biol Phys.* 2011; 81(4): e207-13. doi: 10.1016/j.ijrobp.2011.02.003

# Impact of Education on the Compliance of Nepalese Physical Therapists with Knee Osteoarthritis Clinical Practice Guidelines

Anuradha Shrestha, Roongtiwa Vachalathiti, Sunee Bovonsunthonchai \*

Faculty of Physical Therapy, Mahidol University, Nakhon Pathom, Thailand

## Abstract

**Background:** Even though knee osteoarthritis (OA) is one of the most disabling diseases, it shows that physical therapists in Nepal were not using the clinical practice guidelines (CPGs) for musculoskeletal issues in a quality manner. Evidence-based practice (EBP) has been integrated into the teaching and learning process from the undergraduate level in Nepal however, its inclusion in the curriculum at the university level does not guarantee its practical application. A prior study conducted in Nepal implied that although physical therapists with bachelor's degrees could possess the necessary understanding of evidence search, they might not have sufficient practical skills to put that knowledge to use. Therefore, the study's goal was to investigate how education impacts Nepalese physical therapists' compliance with knee OA CPGs.

**Method:** The survey recorded demographic data and assessed how physical therapists adhered to the CPGs and the most recent evidence. The survey questionnaire was validated by experts and was pretested by five physical therapists to ensure it was relevant and easy to understand.

**Result:** A total of 177 physical therapists responded to the questionnaire. According to the findings, physical therapists with a bachelor's degree complied with 6 out of 15 knee OA CPG statements, compared to those with a master's degree who complied with 5 out of 15 statements. Except for statement 9, a study revealed negligible differences in the groups' compliance to the knee OA CPGs.

**Conclusion:** Both groups showed low compliance to knee OA CPGs, and there was no significant difference in compliance between groups, suggesting that higher education had no bearing on physical therapists' compliance with treatment recommendations. The result of this study may urge physical therapists to consider whether they are following knee OA CPGs and recent evidence in the treatment of patients with knee OA.

**Keywords:** Education; Compliance; Clinical practice guidelines; Knee osteoarthritis; Physical therapy

## 1. Introduction

Knee osteoarthritis (OA) is one of the most common causes of disability in the aging population, resulting in ongoing pain and activity limits [1]. Risk factors for knee OA include obesity, advanced age, gender, and prior knee injuries [2]. The prevalence of knee OA was 16% in adults over the age of 15 and 22.9% was found in those over 40 years [1]. Knee discomfort was reported by 21.5% of respondents in a cross-sectional survey in Nepal, with symptoms of

chronic knee pain present in 50% of those respondents [3]. Suggestions from the clinical practice guidelines (CPGs) [4-6] and previous review studies [7, 8] gave crucial information for physical therapists to focus on treatment effectiveness for knee OA. CPGs are statements that offer suggestions for improving patient care and are backed by various knee OA therapeutic interventions [9]. Physical therapists were strongly recommended by the guidelines to design a course of treatment individually for

---

\* Corresponding author.

E-mail address: sunee.bov@mahidol.edu (Sunee Bovonsunthonchai)

preparing the most effective outcomes [10]. Integrative knowledge gained from CPGs and existing evidence with clinical experience is essential for physical therapy practice to avoid overuse, abuse, and underuse of the treatment [11].

It appears that physical therapists in Nepal may not be implementing CPGs in a competent way to treat musculoskeletal disorders however, there is a lack of supporting evidence to prove this. Some other studies [12, 13] revealed that physical therapists lack the awareness to adhere to knee OA CPGs or existing evidence, although this is one of the most debilitating conditions in educational development nowadays. Therefore, universities must ensure that their students graduated with specialized knowledge, intellectual prowess, and the capacity to apply theory to real-world problems [14]. In comparison to many other nations, Nepal started its physical therapy education extremely late in 2010. Since the undergraduate level in Nepal, evidence-based teaching has been incorporated into the teaching and learning process, and evidence-based practice (EBP) is added as one of the fundamental components of the bachelor's degree. This seeks to develop learners who are inquisitive and knowledgeable about the most recent evidence. However, having an EBP in a university course does not guarantee that the physical therapist will be able to apply the knowledge gained in practice.

Physical therapy program graduates must have skills and personality attributes that will help them advance professionally and adapt to the change rapidly. In addition to having a university degree, physical therapists also need to have a broad range of skills and traits in problem-solving, teamwork, research, assessment, and communication [15]. A previous study conducted in Nepal found that physical therapists with postgraduate degrees outperformed when compared to the ones with bachelor's degrees in terms of knowing research terminology and critically evaluating professional literature [10]. This suggests that physical therapists with bachelor's degree may have appropriate knowledge of evidence search but cannot put that information into practice. Nonetheless, no prior

research has investigated the influence of education on compliance with knee OA CPGs. In line with this, the objective of this study was to investigate how education impacts the compliance with knee OA CPGs in Nepalese physical therapists. This study hypothesized that physical therapists with master's degrees will exhibit higher levels of compliance with knee OA CPGs than those with bachelor's degrees.

## 2. Methods

### 2.1. Study design

This study used a cross-sectional survey to investigate the impact of education on compliance with knee OA CPGs in Nepalese physical therapists.

### 2.2. Ethical consideration

The ethical exemption was approved by the Mahidol University Central Institutional Review Board (MU-CIRB) (COE No. MU-CIRB 2021/261.1910) and the Nepal Health Research Council (NHRC) ethical board (618/2021 MT).

### 2.3. Participants

Participants in this study had more than one year of experience treating patients with knee OA in a variety of work environments, including private clinics, private and government hospitals, rehabilitation facilities, community centers, and private practice.

### 2.4. Procedure

A booklet containing information about this survey research was distributed via an online platform. A survey package was emailed to Nepalese physical therapists who agreed to participate in the study. The survey package included the cover letter, study details, informed consent, and a link to Google Forms. Before taking part in the study, physical therapists had to electronically sign an informed consent. The survey was done over the 3 months from January to March 2022.

In the questionnaire, demographic details were recorded and 15 statements were used to evaluate how closely physical therapists adhered to the CPGs and the most recent evidence (Table 1).

Table 1. Statements and recommendations from CPGs and recent evidence

Statements and recommendations from CPGs and recent evidence
1. All patients with knee OA should get exercise following the Frequency, Intensity, Time, and Type (FITT) approach.
2. In patients with symptomatic knee OA, the use of NSAIDs is advised.
3. Acupuncture is advised for people with symptomatic OA of the knee.
4. It is advised that patients who have a BMI of less than 25 kg/m <sup>2</sup> lose weight.
5. Patients with symptomatic medial compartment knee OA are advised to use lateral wedge insoles.
6. Kinesiotaping is conditionally advised for patients with knee OA as it allows for knee joint range of motion.
7. TENS is used just for brief periods of time for pain relief to complement exercise treatment if an exercise program is impeded by discomfort.
8. Patient-reported outcomes and physical function will not be improved by combining resistance hip exercises with quadriceps workouts.
9. Patients with knee OA are advised to get massage therapy.
10. Total knee arthroplasty (TKA) outcomes are less improved in obese patients.
11. Patients with knee OA following TKA are not advised to engage in continuous passive motion (CPM), passive mobilizations, shock wave therapy, thermotherapy, or ultrasound treatments.
12. Exercise therapy should be personalized and supervised for at least 12 sessions, two sessions per week, to get the necessary therapeutic benefit.
13. In order to alleviate muscle weakness, decreased sensorimotor control, and functional instability, neuromuscular training is beneficial.
14. Radiological imaging is suggested if considerable pathology is found and there has been no improvement after conservative treatment.
15. Patients with knee OA are conditionally advised to perform balance exercises, such as those that help patients better control and stabilize their body position.

The statements were constructed based on recommendations from many CPGs, including the American academy of orthopedic surgeons (AAOS), Osteoarthritis research society international (OARSI), American College of Rheumatology (ACR), Arthritis Foundation Guidelines, and systematic reviews [4-6, 9]. The survey questionnaire was validated by six experts with more than 5 years of experience working in musculoskeletal conditions. In response to their suggestions and comments, the draft of the questionnaire was modified and adjusted. Each item's I-CVI was calculated by dividing the number of experts who rated it 3 or 4 as 1 and 1 or 2 as 0 and then dividing that result by the total number of experts. As a result, the average I-CVI score for this questionnaire was acceptable at 0.97 scores. After that, the pretest was administered by five physical therapists with more than one year of experience who specialize in orthopedic rehabilitation to evaluate its relevance and

comprehensibility as well as to verify the online survey procedure. The participants reported that each question was precise and relevant.

To monitor compliance with knee OA CPGs and recent evidence, physical therapists were asked to respond to statements about the knee OA treatment that were taken from various guidelines and systematic reviews. The level of agreement with the statements was determined using a 5-point Likert scale, which was expressed as 1) Strongly disagree, 2) Disagree, 3) Neither agree nor disagree, 4) Agree, and 5) Strongly agree [16]. The response scores were translated into correct "1" and incorrect "0" for the next analysis. In the evaluation procedure, a score of "1" meant that the participants agreed with the right statement; a score of "0" meant that they disagreed with a right statement or agreed with a wrong statement, or could not decide how to rate the statements. For the level of agreement, we considered the mean score of  $\geq 0.7$  from 1

Table 2. Demographic characteristics (n = 177)

Variables	Mean or number	SD or %
<b>Age (years), (mean and SD)</b>	29.58	4.64
<b>Education level, (n and %)</b>		
Bachelor	116	65.53
Master	61	34.46
<b>Years of experience, (n and %)</b>		
1-10 years	122	68.93
>10 years	55	31.07
<b>Extra training received*, (n and %)</b>		
Taping	78	26.25
Chiropractic	10	3.32
Mobilization	130	43.85
Dry needling	35	11.96
Acupuncture	11	3.65
None	23	10.97

**Note:** SD = standard deviation, n = number, \* Participants have selected multiple options for additional training or credentials about knee OA.

as the acceptable degree of agreement. We evaluated the level of adherence to 15 statements in this study as follows: 7 as low, 7–12 as moderate, and >12 as high.

### 2.5. Sample size estimation

A sample size calculation was performed following a previous survey study (Bajracharya et al., 2019) that took into account the sample size, a 7% margin of error, a 95% confidence interval (CI), and 50% of the projected response rate. As a result, the required sample size of 177 participants was required.

### 2.6. Statistical analyses

The data was entered and analyzed using SPSS version 23 (SPSS Inc., Chicago, IL, USA). The demographic characteristics were calculated using descriptive statistics and reported the data with mean, standard deviation, frequencies, and percentage. The level of significance was set at  $p < 0.05$  for all testing. The analysis of covariance (ANCOVA) was used to investigate compliance to knee OA CPGs between groups with master's and bachelor's degrees with experience and training used as the covariates.

## 3. Results

Over three months of the survey, there were 190 physical therapists responded to the questionnaire. Of this number, 13 were excluded due to they had no recent experience in managing knee OA.

### 3.1. Demographic characteristics

Table 2 displays the participant's demographic data. The participant's average age was  $29.58 \pm 4.64$  years. The majority of participants (65.53%) had a bachelor's degree and had 1–10 years of experience (68.93%). Additionally, a significant proportion of them obtained training in mobilization (43.8%) followed by dry needling (11.96%) and the extent number (10.97%) had no formal training.

### 3.2. Comparison of the compliance to knee OA CPGs and recent evidence between master's and bachelor's degrees physical therapists

Table 3 demonstrated the comparison of compliance to knee OA CPGs and recent evidence between master's and bachelor's degrees physical therapists. From the total of 15 statements in a questionnaire, there were only

Table 3. Comparison of compliance to knee OA CPGs and recent evidence between master's (n = 61) and bachelor's (n = 116) degrees physical therapists (Adjusted means ± SE)

Statements	Adherence to knee OA CPGs		p-value
	Bachelor (mean ± SE)	Master (mean ± SE)	
1. All patients with knee OA should get exercise following the Frequency, Intensity, Time, and Type (FITT) approach.	0.878 ± 0.032	0.876 ± 0.048	0.450
2. In patients with symptomatic knee OA, the use of NSAIDs is advised.	0.537 ± 0.048	0.512 ± 0.072	0.070
3. Acupuncture is advised for people with symptomatic OA of the knee.	0.412 ± 0.046	0.315 ± 0.069	0.829
4. It is advised that patients who have a BMI of less than 25 kg/m <sup>2</sup> lose weight.	0.707 ± 0.044	0.692 ± 0.065	0.550
5. Patients with symptomatic medial compartment knee OA are advised to use lateral wedge insoles.	0.152 ± 0.035	0.185 ± 0.052	0.161
6. Kinesiotaping is conditionally advised for patients with knee OA as it allows for knee joint range of motion.	0.653 ± 0.046	0.476 ± 0.069	0.269
7. TENS is used just for brief periods of time for pain relief to complement exercise treatment if an exercise program is impeded by discomfort.	0.821 ± 0.037	0.729 ± 0.056	0.360
8. Patient-reported outcomes and physical function will not be improved by combining resistance hip exercises with quadriceps workouts.	0.628 ± 0.045	0.543 ± 0.068	0.212
9. Patients with knee OA are advised to get massage therapy.	0.465 ± 0.046	0.424 ± 0.070	<b>0.029*</b>
10. Total knee arthroplasty (TKA) outcomes are less improved in obese patients.	0.317 ± 0.043	0.267 ± 0.064	0.336
11. Patients with knee OA following TKA are not advised to engage in continuous passive motion (CPM), passive mobilizations, shock wave therapy, thermotherapy, or ultrasound treatments.	0.440 ± 0.047	0.366 ± 0.070	0.534
12. Exercise therapy should be personalized and supervised for at least 12 sessions, two sessions per week, to get the necessary therapeutic benefit.	0.766 ± 0.041	0.715 ± 0.061	0.344
13. In order to alleviate muscle weakness, decreased sensorimotor control, and functional instability, neuromuscular training is beneficial.	0.801 ± 0.039	0.754 ± 0.059	0.635
14. Radiological imaging is suggested if considerable pathology is found and there has been no improvement after conservative treatment.	0.453 ± 0.047	0.416 ± 0.071	0.981
15. Patients with knee OA are conditionally advised to perform balance exercises, such as those that help patients better control and stabilize their body position.	0.734 ± 0.041	0.813 ± 0.061	0.623

**Note:** \*p-value tested by the one-way ANCOVA using experience and training as covariates, SE = standard error, FITT = Frequency, Intensity, Time, and Type of exercise, NSAIDs: Nonsteroidal anti-inflammatory drugs, TENS: Transcutaneous electrical nerve stimulation, TKA: Total knee arthroplasty, CPM: Continuous passive motion

6 statements i.e., 1, 4, 7, 12, 13, and 15 scored  $\geq 0.7$ . Likewise, physical therapists with master's degree demonstrated acceptable levels of adherence to 5 of the 15 statements, i.e., 1, 7, 12, 13, and 15, as the scores of  $\geq 0.7$ . Overall, both groups showed low compliance to knee OA CPGs.

As per the ANCOVA analysis (Table 3), physical therapists with master's and bachelor's degrees had equal compliance to knee OA CPGs and recent evidence. In addition, physical therapists with bachelor's degree showed slightly higher compliance to the CPGs and recent evidence than the ones with master's degree for statement 9 [ $F(1,168) = 4.834, p = 0.029$ ].

#### 4. Discussion

This is the first descriptive study on the CPG compliance for knee OA care of physical therapists in Nepal. This study sought to determine how education affected Nepalese physical therapists' compliance with knee OA CPGs and recent evidence.

##### 4.1. Demographic characteristics

The demographics of the participants had a mean age of 29.58 years, showing that Nepalese physical therapists were primarily younger. Similar to those of a prior study [17], which discovered that Indian physical therapists were, on average, 26.09 years old. In addition, a significant proportion of physical therapists with bachelor's degrees in this study was similar to the other studies [10, 17, 18]. According to a prior study [19], physical therapists' clinical judgments were influenced by their educational background, which can be used to determine whether or not they were adhering to treatment standards. In addition, around two-thirds of participants had less than ten years of experience treating patients with knee OA. Furthermore, the majority of them had multiple training workshops, such as mobilization, taping, chiropractic, etc., while only a small percentage of physical therapists had no formal training. The ability to develop a suitable exercise program for patients with knee OA may be aided by formal training in addition to university education [20], but it is unclear

whether this will affect the PT's adherence to treatment recommendations.

##### 4.2. Comparison of the compliance to knee OA CPGs between physical therapists with master's and bachelor's degrees

The results of our study showed that physical therapists with master's and bachelor's degrees only agreed on less than half of the 15 statements of the knee OA CPGs, indicating low compliance. Physical therapists with bachelor's degrees agreed with 6 out of 15 statements on CPGs and recent studies on managing knee OA, compared to those with master's degrees who agreed with 5 out of 15 statements. Though both groups had low compliance to knee OA CPGs, physical therapists with bachelor's degrees somehow showed better compliance than those with master's degrees. In comparison to physical therapists with master's degree, those with bachelor's degree appeared to comply to statement no. 4 on weight loss advice for patients with  $BMI \geq 25 \text{ kg/m}^2$ . This finding was consistent with guidelines recommendations [5] and similar to the findings of Battista et al. [13]. Furthermore, it was discovered that the majority of participants in both groups agreed with statement 1 which were aware of the FITT concept when suggesting exercise to patients with knee OA. It has been found that different exercise types, intensities, durations, and frequencies have varying effects on OA patients [21]. Participants were found to comply with statement 12 which emphasized the need for clinically beneficial exercise. According to Skou et al. review study, a minimum of 12 supervised sessions held at least three times per week are necessary to produce higher outcomes [22]. Participants were also aware that neuromuscular exercise can help cure knee OA by reducing muscle weakness, enhancing sensorimotor control, and reducing functional instability [5, 23]. Participants were also aware of the conditional recommendation for balance exercises for knee OA, which was in line with the ACR recommendation [6].

With the exception of statement 9, the findings of our study revealed no significant differences in the compliance to knee OA CPGs

between physical therapists with master's and bachelor's degrees. This result was consistent with a prior study by Akodu et al. [12], which found no statistically significant correlation between respondents' level of education and adherence to clinical practice guidelines. Statement 9 addressed the use of massage therapy in patients with knee OA, which in accordance with the ACR guidelines, has advised against its use [6]. Both physical therapists with master's and bachelor's degrees were aware of the information that opposed the use of massage therapy in the treatment of knee OA, but when experience and training were considered, physical therapists with bachelor's degrees fared slightly better. This implies that graduates with a bachelor's degree may adhere to the treatment standards which may be due to adequate training and sufficient experience. In addition, the overall results showed no significant impact of education on the compliance to knee OA CPGs and recent evidence in Nepalese physical therapists.

In contrast to a prior study by Bajracharya et al. [10], where they found that physical therapists with master's degrees were more knowledgeable about research techniques and terminology, but both groups in our study showed comparable compliance to knee OA CPGs. A recent nationwide study conducted in Nepal [24], found that more than half of physical therapists reported a lack of enabling legislation and a lack of competencies as obstacles to the use of evidence-based physical therapy. This may help to explain why the majority of physical therapists in our study had insufficient compliance with knee OA CPGs. However, they were shown to be acquainted with guidelines and suggestions after ongoing skill development and training. Nonetheless, Nepalese physical therapists still have a ways to go before adopting the evidence-based practice.

Despite the statistically significant differences found in just one statement in this study, scores were not differing much between the two groups of participants. Therefore, the practical interpretation of the data was limited. There are some limitations of this study that need to be discussed. Firstly, we did not investigate the

Nepalese physical therapists' treatment pattern for knee OA and secondly, we did not look at the participants' practice settings (such as private clinics, hospitals, rehabilitation, community, etc.), which would have had an impact on how closely they followed CPGs.

## 5. Conclusion

In our study, both the groups with master's and bachelor's degrees showed low compliance to knee OA CPGs and there was no discernible difference between the groups in terms of their compliance with knee OA CPGs. This finding suggested that higher education did not impact physical therapists' degree of compliance with knee OA CPGs and recent evidence.

## Recommendations

As the study's results showed no noticeable difference in compliance with knee OA CPGs between physical therapists with master's and bachelor's degrees, future research can concentrate on exploring probable causes of this low compliance to treatment guidelines irrespective of their educational status. The additional study can look into their work environments and their clinical practice in greater detail to see if it complies or not with suggestions. The findings of this study can assist Nepalese physical therapists in critically evaluating their compliance with treatment recommendations for knee OA.

## Acknowledgments

We appreciate everyone who took part in this study for their outstanding efforts. We value the representative of the Nepal Physiotherapy Association's help in disseminating the survey questionnaire broadly across the state of Nepal. Finally, we would like to thank Mahidol Graduate Scholarships 2020 for financially supporting the study of this master's program.

## References

- [1] Cui A, Li H, Wang D, Zhong J, Chen Y, Lu H. Global, regional prevalence, incidence and risk factors of knee osteoarthritis in population-based studies. *EClinicalMedicine*. 2020; 29-30: 100587. doi: 10.1016/j.eclinm.2020.100587

- [2] Blagojevic M, Jinks C, Jeffery A, Jordan KP. Risk factors for onset of osteoarthritis of the knee in older adults: a systematic review and meta-analysis. *Osteoarthritis Cartilage*. 2010; 18(1): 24-33. doi: 10.1016/j.joca.2009.08.010
- [3] Kshetri D, Selfe J, Sutton C, Rouse K, Dey P. Prevalence of knee pain differs across ecological landscapes of the Western Development Region of Nepal. *PRM+*. 2019; 1(3): 73-7.
- [4] Bannuru RR, Osani MC, Vaysbrot EE, Arden NK, Bennell K, Bierma-Zeinstra SMA, et al. OARSI guidelines for the non-surgical management of knee, hip, and polyarticular osteoarthritis. *Osteoarthritis Cartilage*. 2019; 27(11): 1578-89. doi: 10.1016/j.joca.2019.06.011
- [5] Jevsevar DS. Treatment of osteoarthritis of the knee: evidence-based guideline, 2<sup>nd</sup> edition. *J Am Acad Orthop Surg*. 2013; 21(9): 571-6. doi: 10.5435/JAAOS-21-09-571
- [6] Kolasinski SL, Neogi T, Hochberg MC, Oatis C, Guyatt G, Block J, et al. 2019 American College of Rheumatology/Arthritis foundation guideline for the management of osteoarthritis of the hand, hip, and knee. *Arthritis Care Res (Hoboken)*. 2020; 72(2): 149-62. doi: 10.1002/acr.24131
- [7] Golightly YM, Allen KD, Caine DJ. A comprehensive review of the effectiveness of different exercise programs for patients with osteoarthritis. *Phys Sportsmed*. 2012; 40(4): 52-65. doi: 10.3810/psm.2012.11.1988
- [8] Gourdine J. Review of nonsurgical treatment guidelines for lower extremity osteoarthritis. *Orthop Nurs*. 2019; 38(5): 303-8. doi: 10.1097/NOR.0000000000000591
- [9] van Doormaal MCM, Meerhoff GA, Vliet Vlieland TPM, Peter WF. A clinical practice guideline for physical therapy in patients with hip or knee osteoarthritis. *Musculoskeletal Care*. 2020; 18(4): 575-95. doi: 10.1002/msc.1492
- [10] Bajracharya S, Tharu NS, Bokaliyal D. Knowledge, attitude and barrier to evidence-based practice among physiotherapists in selected districts of Nepal. *J Nepal Health Res Counc*. 2019; 17(2): 215-21. doi: 10.33314/jnhrc.v0i0.1711
- [11] Scurlock-Evans L, Upton P, Upton D. Evidence-based practice in physiotherapy: a systematic review of barriers, enablers and interventions. *Physiotherapy*. 2014; 100(3): 208-19. doi: 10.1016/j.physio.2014.03.001
- [12] Akodu AK, Osundiya OC, Ajepe TO, Jegede OM. Management of knee osteoarthritis: Knowledge and adherence to clinical practice guidelines among physiotherapists in selected hospitals in Lagos state, Nigeria. *Afr J Biomed Res*. 2020; 23(3): 327-33.
- [13] Battista S, Salvioli S, Millotti S, Testa M, Dell'Isola A. Italian physiotherapists' knowledge of and adherence to osteoarthritis clinical practice guidelines: a cross-sectional study. *BMC Musculoskelet Disord*. 2021; 22(1): 380. doi: 10.1186/s12891-021-04250-4
- [14] Sharma S. Impact of higher education on Indian physiotherapy. *Int J Sci Res*. 2018; 7(3): 32-3.
- [15] Hunt A, Adamson B, Higgs J, Harris L. University education and the physiotherapy professional. *Physiotherapy*. 1998; 84(6): 264-73. doi: 10.1016/s0031-9406(05)65527-7
- [16] Sullivan GM, Artino AR, Jr. Analyzing and interpreting data from likert-type scales. *J Grad Med Educ*. 2013; 5(4): 541-2. doi: 10.4300/JGME-5-4-18
- [17] Saha P, Yangchen T, Sharma S, Kaur J, Norboo T, Suhail A. How do physiotherapists treat people with knee osteoarthritis and their evidence awareness: a cross-sectional survey among Indian physiotherapists. *Int J Physiother Res*. 2021; 9(4): 3968-73. doi: 10.16965/ijpr.2021.161
- [18] Dao HT, Pichaiyongwongdee S, Sullivan PE, Prasertsukdee S, Apinonkul B. Are physical therapists in Viet Nam ready to implement evidence-based practice? A survey. *BMC Med Educ*. 2018; 18(1): 317. doi: 10.1186/s12909-018-1428-3
- [19] Wainwright SF, Shepard KF, Harman LB, Stephens J. Factors that influence the clinical decision making of novice and experienced physical therapists. *Phys Ther*. 2011; 91(1): 87-101. doi: 10.2522/ptj.20100161
- [20] Holden MA, Nicholls EE, Hay EM, Foster NE. Physical therapists' use of therapeutic exercise for patients with clinical knee osteoarthritis in the United kingdom: in line with current recommendations? *Phys Ther*. 2008; 88(10): 1109-21. doi: 10.2522/ptj.20080077
- [21] Kong H, Wang XQ, Zhang XA. Exercise for osteoarthritis: a literature review of pathology and mechanism. *Front Aging Neurosci*. 2022; 14: 854026. doi: 10.3389/fnagi.2022.854026

- [22] Skou ST, Roos EM. Physical therapy for patients with knee and hip osteoarthritis: supervised, active treatment is current best practice. *Clin Exp Rheumatol*. 2019; 37 Suppl 120(5): 112-7.
- [23] Tayfur B, Morrissey D, Miller SC. Neuromuscular alterations in knee osteoarthritis: a systematic review and meta-analysis. *Osteoarthritis Cartilage*. 2020; 28: S218-9. doi: 10.1016/j.joca.2020.02.357
- [24] Nepal GM, Acharya RS, Coppieters MW, Bimali I, Poudel S, Chaudhary B, et al. The physiotherapy workforce in Nepal: a national survey. *J Eval Clin Pract*. 2022: 1-14. doi: 10.1111/jep.13729

# Knee Kinetics and Kinematics during *Ten-Sao* Dance: A Comparison between Khon Masked Dancers and Non-dancers

Pakamas Jearudomsup, Sunee Bovonsunthonchai,  
Roongtiwa Vachalathiti, Pagamas Piriyaprasarth, Warin Krityakiarana \*

Faculty of Physical Therapy, Mahidol University, Nakhon Pathom, Thailand

## Abstract

**Background:** The Khon masked dance is an authentic Thai classical performance that has been relinquished for centuries. "*Ten-Sao*", the basic training movement is maintained in the semi-squat or knee flexion and varus with toes out throughout the performance. The excessive knee flexion and varus position could exhibit an impact force and stress on the knee structures and leads to knee injury risk. The evidence of *Ten-Sao* related to the knee kinetics (knee joint force and ground reaction force) and kinematic (knee joint angle) information remains far from obvious.

**Methods:** This research presented a study of the comparisons of kinetics and kinematics over the starting and leg rising phases of *Ten-Sao* between Khon masked dancers and non-dancers. Twenty healthy males, including Khon masked dancers ( $n = 10$ ) and non-dancers ( $n = 10$ ) participated in the study. All participants performed *Ten-Sao* 10 cycles, then the kinetics and kinematics of starting and leg rising phases were investigated using 3D motion analysis and force plates.

**Results:** For kinetics, the findings showed lower knee anterior ( $p = 0.009$ ) and inferior ( $p = 0.001$ ) joint forces in Khon masked dancers when compared to the non-dancers at the starting phase. Moreover, Khon masked dancers showed lower medial ( $p = 0.012$ ) and vertical ( $p < 0.001$ ) ground reaction forces at the starting phase. For kinematics, Khon masked dancers had lower knee varus angle ( $p = 0.038$ ) at the starting phase but had higher knee internal rotation angle ( $p = 0.028$ ) at leg rising phase. The reduced joint force and ground reaction force are achieved by decreasing knee varus and external rotation, both of which contribute to less stress on the knee structures and involve the dance technique. However, leg raising with a high knee internal rotation could be a cause of increased compression and tension on the knee joint.

**Conclusion:** The results obtained from this study might provide the knee biomechanics evidence of *Ten-Sao* and be used in the prevention, development, and movement suggestion for Khon masked dancers.

**Keywords:** Thai classical performance, Khon masked dance, Knee joint, Biomechanics, Injury prevention

## 1. Introduction

Dance is an art performance that refers to a series of body movements performed with music or rhythm to express aesthetics, body language, emotions, and feelings through body motion [1]. The application of dance biomechanics has been investigated as an element of particular movement by analyzing the internal and external

forces, moments, and repeated motion over the body, both the whole and each linked segment [2, 3]. The measuring kinetics and kinematics of a dancer's body could be useful to determine the required mechanical body based on the joint motion and force action on the body [2, 3]. Dance injury commonly occur as musculoskeletal injuries, especially at the lower extremities (LEs),

\* Corresponding author.

E-mail address: warin.kri@mahidol.edu (Warin Krityakiarana)

and present up to 66–86% of all injuries in ballet dancers [4-6]. The three most common types of injuries were tendinitis 22.81%, sprain 16.67% and strain 14.91% [6]. The majority of injuries are chronic and overuse micro-trauma due to repetitive movement and incorrect dance technique [7, 8]. Knee injuries were found to be the most common (15%-29%), with an incidence rate of 1.9 per 1,000 hours of dance exposure [4, 6, 9]. Interestingly, the most common injuries in Thai classical dancers also occurred at the knee by 23% and 13% in amateur and professional dancers, respectively [10].

“Khon Thai masked dance” is a famous Thai dramatic art performance that is a heritage transmitted from generation to generation in Thailand [11, 12]. Khon masked dance is not only important in Thai tradition, but it also improves physical activity by demanding the use of muscles to perform each position properly [13]. Khon masked dance has four main role plays, included the god, angel, giant and monkey characters [11]. The role of giant and monkey characters has required the more physical actions and strengthening of lower limbs [13, 14]. These characters had been trained the important specific Khon masked dances, is called “*Ten-Sao*” (or step at a pole) (Fig. 1). Khon masked dancers usually being trained using the semi-squat position (hip flexion, abduction, and external rotation) with knee flexion separated, varus, and feet toe-out. By lifting a single leg up and slapping the legs on

the floor, alternatively on the left and right sides, along with rhythm, will appear as the specialized dance performance [15, 16].

According to the element of *Ten-Sao* in starting position, maintaining knee bending, varus, and external rotation position is similar to *Demi-plié* (semi-squat, knee bending, varus, and feet-out to 180°) of ballet dance. The continued external rotation of this posture could be a cause of knee ligament injury due to the force through stress on the knee joint, also known as screwing the knee [17]. Furthermore, the starting posture is similar to an outward squat, which compresses the knee joint by increasing the load on the medial side and leads to an increased risk of osteoarthritis (OA) [18]. Gontijo et al. found that almost all dancers presented knee kinematics with a medial misalignment during *Demi-plié*. The tension accumulated on the medial collateral, and the standing torsional force could influence the internal capsule at the knee joint [19]. The constantly deep knee bending with required hip external rotation and abduction lead to the knee being screwed outwardly for compensation based on the kinematic chain and could be a risk factor for soft tissue tightness [17, 20]. Moreover, the dancers act out the knee flexion, varus, and internal rotation, which are related to the screw home mechanism at the leg rising position [21]. This posture also involves more tension and load on the anterior cruciate ligament (ACL) for pulling the knee [22]. Similarly, in the open kinetic chain

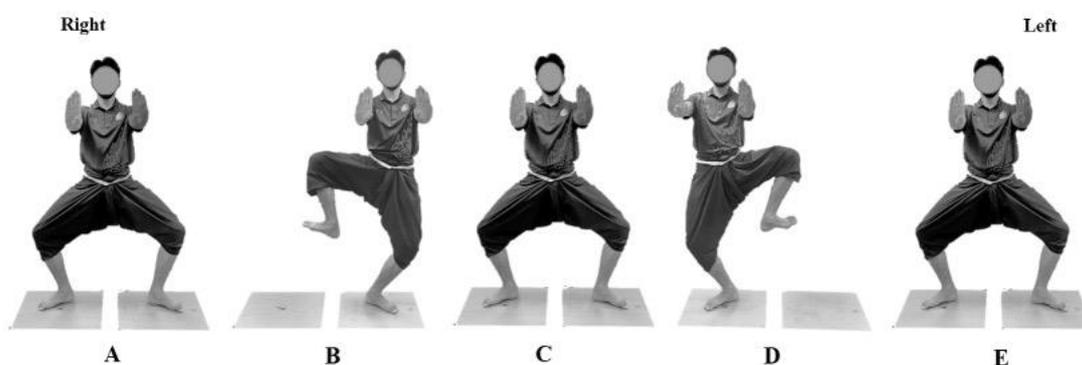


Fig. 1. The *Ten-Sao* task composes of starting phase (A) right leg is raised with left leg remaining placed on a force plate (leg rising phase) (B), right leg slapped on a force plate (C), left leg is raised (D), and left leg slapped on a force plate as an ending position (E), respectively. This pattern from (A) to (E) is counted as one dancing cycle.

of the knee joint, the over posterior shear force could occur on the posterior cruciate ligament when the knee was flexed [23]. At the same time, the meniscus has to support the knee flexion and rotation during shear force happening between tibial and femoral condyles and this could lead to the risk of meniscus injury in dancers [21, 24]. A previous study also found the increased knee varus which probably led to lateral collateral ligament (LCL) injury due to the increase in medial lever arm and enhance lateral reaction to prevent the injury [25].

As mentioned above, the out-of-natural anatomical positions, including semi-squat and prolonged knee flexion with varus, might contribute to the risk of knee injuries by force, tension, and load or even compensation for this movement. Furthermore, the different characteristics of dancers and non-dancers might contribute to the variability of knee kinetics and kinematics based on skill performance. The evidence of *Ten-Sao* in some parts of kinetics and kinematics remains unclear. Thus, this study presented the comparisons of kinetics and kinematics over the starting and leg-rising phases of *Ten-Sao* between Khon masked dancers and non-dancers. The expected outcome can identify the significant differences in knee kinetics and kinematics over the starting and leg-rising phases of *Ten-Sao* between Khon masked dancers and non-dancers. This study provided knee biomechanics evidence of *Ten-Sao* for better understanding and can be used in appropriate prevention and movements.

## 2. Methods

### 2.1. Study Design

The study design is cross-sectional and the data were collected in the motion analysis laboratory room at the Faculty of Physical Therapy, Mahidol University, Salaya Nakhon Pathom, Thailand. This study used a convenience sampling technique.

### 2.2. Participants

The study included twenty healthy males, of which 10 were Khon masked dancers and 10 were non-dancers [26]. The inclusion criteria of all

participants were aged 20-40 years, Body mass index (BMI) of 18.5-30.0 kg/m<sup>2</sup>. For Khon masked dancers, they shall play giant or monkey characters with at least 5 years of Khon dance experience and were recruited from The College of Dramatic Arts (Bunditpatanasilpa Institute). For non-dancers were those without dance experience. Participants who had low back pain or pain at LEs within 24 hours of data collection, a history of LEs injury or surgery within the previous 6 months, had been trained in sport training programs as athletes, professional or other types of dance, and asymmetrical leg length (leg length discrepancy greater than 1 cm.) were excluded.

### 2.3. Procedure

All participants provided a written informed consent approved by the Mahidol University-Central Institutional Research Board (MU-CIRB) before participating in the study. This study used 3D motion analysis (VICON Motion System, Oxford Metrics, UK) with 10 Vantage cameras and AMTI force plate (series OR67, Watertown, USA). The system has proven of good to excellent test-retest reliability with intraclass correlation coefficients (ICCs) of 0.84-0.99 and high test-retest reliability (ICC of 0.97-0.99) in previous studies [27, 28]. Participants wore shorts and sixteen reflective markers (14 mm diameters) were attached to anatomical bony landmarks on both sides based on the Plug-in-Gait LEs model [29]. The 3D motion analysis and force plate were calibrated by static standing posture before data collection.

Before a real data collection, participants were asked to practice *Ten-Sao* dance session. It includes the starting posture with the trunk properly upright, arms straight forward parallel to the floor, and wrists in extension. The LEs were in the semi-squat position with hip flexion and external rotation, knee bending with varus and external rotation, and feet toe-out (starting phase) (Fig. 1A). Then, participants raised the right leg up with the left leg remaining placed on the force plate (leg rising phase) (Fig. 1B). Next, participants moved the right leg slapped on the force plate, then the left leg raised, and finally,

the left leg slapped on a force plate as an ending position, respectively (Fig. 1C-E). This pattern was counted for one dancing cycle. Khon masked dancers were allowed to practice *Ten-Sao* for 30 cycles with one minute of resting time every 10 cycles. Non-dancers were asked to read the *Ten-Sao* movement guidelines. Then, they observed the *Ten-Sao* video for one minute and practiced for 10 cycles. The one-minute video observation and 10 cycles of dance were counted as one set. Non-dancers were required to complete three sets for this practice session. All participants rested for five minutes before the actual data collection started. During actual data collection, the participants performed *Ten-Sao* as mentioned above, with one leg on each force plate (Fig. 1A-E). The participants continuously did this movement until completing 10 cycles, along with a metronome application of 56 beats per minute [30]. The *Ten-Sao* movement was guided by a metronome set at 56 beats/min during practice and data collection. Data from 10 cycles were collected, and three (the 4<sup>th</sup> to 6<sup>th</sup>) cycles over the starting and leg rising phases were analyzed for comparisons between the two groups (Fig. 1A-B). If participants failed to perform this task or lost markers, they were asked to stop action and all steps were repeated.

#### 2.4. Outcomes

This study investigated knee kinetics and kinematics at the starting phase and kinematics at the leg rising phase. The kinetics included the knee joint force (anterior/posterior; Ant/Post, medial/lateral; Med/Lat, and superior/inferior; Sup/Inf) and ground reaction forces (GRFs) in three planes (anterior/posterior; Ant/Post, medial/lateral; Med/Lat, and vertical; V) and the kinematics included the knee joint angular motion in three planes of movement (flexion/extension; Flex/Ext, Varus/Valgus and internal rotation/external rotation; Int Rot/Ext Rot).

#### 2.5. Data deduction process

The kinetic and kinematic data were filtered using the low-pass Butterworth filtering method, with 35 and 10 Hz cut-off frequency, respectively.

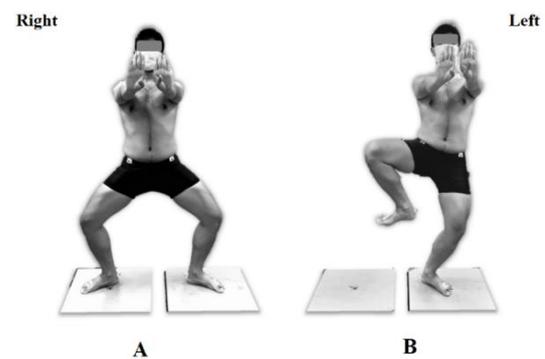


Fig. 2. The *Ten-Sao* task from the starting phase (A) to the right leg raise with the left leg remaining placed on the force plate (leg rising phase) (B).

All data were extracted in the middle part of the starting phase (Fig. 2A). The knee joint angles were analyzed at the maximum point of knee flexion angle over the leg rising phase (Fig. 2B). The kinetics and kinematics of the dominant leg were averaged from three (the 4<sup>th</sup> to 6<sup>th</sup>) cycles in each phase and were used for the comparison between the Khon masked dancers and non-dancers.

#### 2.6. Statistical Analysis

All statistical analysis of the *Ten-Sao* task was evaluated using the SPSS (Statistics for Windows version 23.0, NY, USA). Descriptive statistics were used to describe demographic characteristics. The Shapiro-Wilk test was used to test data distribution and showed normal distribution. The independent sample t-test was used to compare the mean of kinetic and kinematic variables between the two independent groups. The level of confidence is set at  $\alpha$  level = 0.05 for all statistical analyses.

### 3. Results

#### 3.1. Participant characteristics

Characteristics of the participants had no significant differences between the two groups (Table 1). The average age of the Khon masked dancers was  $22.80 \pm 3.26$  years, weight  $70.53 \pm 14.97$  kg, height  $171.47 \pm 3.5$  cm, BMI  $23.78 \pm 4.36$  kg/m<sup>2</sup>, and with dance experience of  $9.20 \pm 2.90$  years. The average age of the non-dancers was  $24.00 \pm 6.29$  years, weight  $68.85 \pm 14.63$  kg,

Table 1. Characteristics of Khon masked dancers and non-dancers, (n(%) or Mean ± SD)

Characteristics	Participants (n = 20)		P-value
	Dancer (n = 10)	Non-dancer (n = 10)	
Age (years)	22.80 ± 3.26	24.00 ± 6.29	0.601
Weight (kg)	70.53 ± 14.97	68.85 ± 14.63	0.803
Height (cm)	171.47 ± 3.51	175.24 ± 8.74	0.230
Body Mass Index (BMI) (kg/m <sup>2</sup> )	23.78 ± 4.36	22.22 ± 3.32	0.382
<b>Dominant leg</b>			
Right	10 (100%)	10 (100%)	n/a
Left	0 (0%)	0 (0%)	n/a
Training experience (years)	9.20 ± 2.90	n/a	n/a
Leg length discrepancy (cm)	0.17 ± 0.22	0.17 ± 0.21	0.975

kg = kilogram, cm = centimeters, m<sup>2</sup> = square meters, n = the number of participants, n/a = not assessed, \* = significant difference tested by the independent sample t-test at p < 0.05

Table 2. Knee kinetic and kinematic variables at the starting and leg rising phase for Khon masked dancers and non-dancers, (Mean ± SD)

Phase of Ten-Sao		Groups		P-value
		D (n = 10)	ND (n = 10)	
<b>A. Starting position phase</b>				
Joint force (N/kg)	+Ant/-Post	1.11 ± 0.30	1.68 ± 0.55	0.009*
	+Med/-Lat	-0.44 ± 0.25	-0.86 ± 0.60	0.053
	+Sup/-Inf	-3.08 ± 0.37	-4.19 ± 0.75	0.001*
GRF(N/kg)	+Ant/-Post	-0.16 ± 0.55	0.14 ± 2.03	0.658
	+Med/-Lat	5.05 ± 1.21	7.14 ± 2.04	0.012*
	+Vertical	39.48 ± 4.29	54.26 ± 7.79	< 0.001*
Joint angle (degree, °)	+Flex/-Ext	28.84 ± 12.73	32.67 ± 14.42	0.537
	+Varus/-Valgus	16.86 ± 7.39	24.70 ± 8.25	0.038*
	+Int Rot/-Ext Rot	-8.92 ± 10.88	-9.24 ± 11.34	0.951
<b>B. Leg rising phase</b>				
Joint angle (degree, °)	+Flex/-Ext	130.56 ± 14.31	113.35 ± 26.08	0.084
	+Varus/-Valgus	36.94 ± 13.05	44.98 ± 11.71	0.164
	+Int Rot/-Ext Rot	37.60 ± 11.57	23.07 ± 15.32	0.028*

n = the number of participants, ° = Degree(s), +Ant/-Post = +Anterior/-Posterior, +Med/-Lat = +Medial/-Lateral, +Sup/-Inf = +Superior/-Inferior, +Flex/-Ext = +Flexion/-Extension, +Int Rot/-Ext Rot = +Internal Rotation/-External Rotation, D=Dancer group, ND=non-dancer group, \* = significant difference tested by the independent sample t-test at p < 0.05

height 175.24 ± 8.74 cm, BMI 22.22 ± 3.32 kg/m<sup>2</sup> (Table 1).

3.2. Comparison of knee kinetic and kinematic variables at the starting and leg rising phases between Khon masked dancers and non-dancers

Table 2 demonstrated the comparison of knee kinetic and kinematic variables at the starting and leg rising phases between Khon masked dancers

and non-dancers. At the starting phase, significant lower anterior (p = 0.009) and inferior (p = 0.001) knee joint forces were found in Khon masked dancers when compared to non-dancers while the lateral knee force showed no difference (p = 0.053). For GRF, significant lower medial (p = 0.012) and vertical GRFs (p < 0.001) were found in Khon masked dancers and no difference was found in anteroposterior GRF between the

two groups. For joint angle, a significantly lower varus angle ( $p = 0.038$ ) was found in Khon masked dancers while no difference was found in the other two planes of knee joint angle. At the leg rising phase, a significantly higher internal rotator angle ( $p = 0.028$ ) was found in Khon masked dancers while the other two planes of angle showed no difference.

#### 4. Discussion

The main findings of this study were that Khon masked dancers had significantly lower knee anterior and inferior joint forces, medial and vertical GRFs, and knee varus angle when compared to the non-dancers at the starting phase. In addition, Khon masked dancers performed a significantly higher knee internal rotation angle at the leg rising phase.

At the starting phase, the knee anterior joint force might be generated by using the knee flexion angle and the convex-concave rule as the coupled movement of knee flexion and translation [31, 32]. Khon masked dancers presented lower knee flexion angle, which could be the result of producing lower knee anterior joint force than non-dancers. Previous evidence suggested that the low flexion pattern of dancers may be the result of improved lower extremity stabilization [33]. Moreover, Khon masked dancers might have efficient muscle co-contraction, which could reduce the knee anterior joint force, gain more joint stability based on the lower knee flexion angle during weight-bearing posture [34]. The decreased knee anterior joint force was improved by the co-contraction of hamstring and quadriceps activation, which can reduce the tensile loading on the anterior cruciate ligament [18]. The appropriate range of motion (ROM) such as the low knee flexion angle with low anterior joint force of dancers and leg muscle strengthening, could be a result of the injury prevention technique for their performance based on neuromuscular training [35].

This task resembles the closed kinematic chain motion and is similar to the semi-squat or early descending squat. The squat motion requires coordinating the flexion and extension movements of the hip, knee, and ankle joints,

which could create a compressive joint force on the knee in the case of inappropriate movements [36]. It has been presented that unrestricted squat with more knee flexion angle leads to increased load and compression by the greater knee moment and longer moment arm of GRF [37]. Moreover, the more knee flexion the greater tibia twisting or rotation mobility [38]. In contrast, the current study found that Khon masked dancers presented a decreased knee inferior joint force, which was related to the low knee flexion and external rotation angle when compared to non-dancers. During the descending phase of the squat, the inferior force was decreased by the low knee flexion angle due to the decreased tension between the patella and quadriceps tendon [18]. Although, this study had no exact identification of the restricted or unrestricted squat posture, dancers might be trained to improve the way to prevent excessive flexion for knee compression decreasing. It has been reported that the knee compression force during performance or training in was decreased in experienced dancers [39].

Regarding the previous literature, the low inferior joint force might provide the decline of medial and vertical GRFs based on the force line direction and reaction force of body weight transferred to the medial femoral condyle [40]. Previous research explained that dancers were able to reduce lower vGRF by decreasing knee joint stiffness and creating a greater vertical displacement of center of mass (COM) [41]. It has been reported that experienced dancers had lower vGRF than novice dancers and the reduced vGRF was obtained by the greater knee flexion angle as the soft landing technique [33, 42]. The current study observed that Khon masked dancers performed the lower vGRF, which might benefit the low risk of knee injuries, but presented with decreased knee flexion. The difference in population and tasks, such as landing versus *Ten-Sao* dance, might be reasons for the variance in results. The medial GRF was offered by the excessive knee varus angle due to the load transmitted through the medial compartment with a greater creating moment arm [43]. According to previous research, greater knee adduction can provide 70-75% force pass on the medial side

[44]. Agreement with previous dance study investigated the *Demi-plie'*, found the medial misalignment and created tension on the medial collateral, which could influence to compress the internal capsule at the knee joint [19]. The current study, the low medial GRF of Khon masked dancers might be a result of decreased knee varus angle when compared to non-dancers.

Normally, the knee varus angle is increased by the unlocking of tibial twisting during knee flexion around 30° [38, 45]. According to the close kinematic chain in this posture, the femur rotated externally with knee flexion, leading to an increase in the knee varus angle and related to the production of the lateral joint force [46]. The greater knee varus alignment was produced in slight knee flexion, which could increase the lateral compartment opening [45]. It has been reported that dancers performed greater knee varus alignment, causing them to exhibit larger frontal plane joint excursions [47]. Our study found that Khon masked dancers performed low knee varus angle and also observed low knee flexion, meaning that the significant low knee varus angle could be generated by the reduced knee flexion, external rotation, as well as referring to releasing the lateral joint force when compared with non-dancers. Moreover, the reduction of knee varus was associated with a wide stand and a larger toe out angle during the squat [48]. Khon masked dancers were usually trained on the wide stand width based on basic posture training, known as *Tèep-Liïam* (square squat with hip flexion, external rotation, knee bending, and feet toe-out as parallel on the floor) [16]. This training posture might influence the decreased knee varus angle and the types of dance with specific task training may be the causes of varying outcomes.

Interestingly, the anterior-posterior GRF of the two groups was contrasted with each other. Khon masked dancers showed the posterior GRF, whereas non-dancers performed the anterior GRF. The straight arm forward of *Ten-Sao* dance might lead to the COM shifting anteriorly on the base of support, which Khon masked dancers who practiced the erect trunk posture might be able to adjust in more posterior GRF to reduce

the postural sway and be more graceful during performance [49, 50]. A previous study investigated the *Koshiwari* movement, known as "Sumo Squat" (feet shoulder-width apart, hip and knee external rotation, feet pointed outwards, trunk and lower leg maintained in a vertical line) and observed the center of gravity is located slightly posterior [36]. Meanwhile, non-dancers might lean more forward, which could create a more anterior GRF following the COM from the straight arms.

At the leg rising phase, this posture presented the reverse pattern of the screw home mechanism by the knee internal rotation at nearly full knee flexion [51]. When the tibia moves on the femur, the tibial internal rotation is created to unlock the knee joint during maximum knee flexion [22]. This mechanism could be the cause of higher internal rotation with increased knee flexion in Khon masked dancers than non-dancers. Moreover, Khon masked dancers performed higher knee flexion in order to achieve the *Nèep-Nông* posture (maximum knee flexion with squeezed calf muscle as much as you can do during the leg rising phase) following *Ten-Sao* dance training [16]. A previous study explored the *Passe'* position (weight shift to one limb and moving hip flexion, knee flexion, and ankle plantar flexion at the gesture limb), dancers presented the highest angular displacement at the knee flexion around 107°-130° [52]. This is consistent with Blazkiewicz [53], who studied the *Pirouette* (ballet turn with one leg supporting position) and dancers showed significantly higher knee joint angle in all planes and the greatest knee flexion angle on the gesture leg. It has been presented that the knee internal rotation at maximal knee flexion is a result of increased compression and getting the twisting strain on the knee joint [18]. Wan and Shan [54], added to the evidence that greater ROM, over-lengthening, and imbalance between agonist and antagonist muscles are causes of micro-trauma injuries in dancers and lead to repetitive strain injury (RSI) syndrome. The low knee varus of Khon masked dancers might be related to the knee tightening by increased pressure and joint capsule shortening during full knee flexion and internal rotation [31].

However, there was no significant difference between the two groups.

The findings of current study could relate to knee biomechanical knowledge and could be applied to describe the mechanism of knee kinetics and kinematics in *Ten-Sao* dance. However, this study had some limitations. First, the number of participants was small. A larger number of participants is recommended for further investigation. Second, this study investigated only the starting and leg rising phases, which might not be enough to explain all the biomechanics in the entire motions of *Ten-Sao* dance.

## 5. Conclusion

*Ten-Sao* dance obviously provided different knee kinetics and kinematics at the starting and leg-rising phases when compared between Khon masked dancers and non-dancers in all three planes. For kinetics, Khon masked dancers performed significantly lower knee anterior and inferior joint forces, as well as lower medial and vertical GRFs than non-dancers at the starting phase. For kinematics, Khon masked dancers had a significantly lower knee varus angle at the starting phase but had a significantly higher knee internal rotation angle at the leg-rising phase than non-dancers. The reduced joint force and GRFs are achieved by decreasing knee varus and external rotation with knee flexion during the starting phase. These contribute to less stress on the knee structures and involve the dance technique. However, leg raising with a high knee internal rotation of dancers could be a cause of increased compression and tension on the knee joint and should be more carefully considered. Additionally, to reduce the risk of knee injuries, this specific task or other similar knee or lower limb motions should be correctly instructed by professionals, particularly in non-dancers. Overall, the findings of current study may be beneficial in better understanding knee biomechanics, injury prevention, and appropriate movement suggestions for Khon masked dancers and non-dancers.

## Further Study

Knee is one of the crucial joints of LE function and could affect other parts of the body's

movement. Therefore, future studies should concern the kinematics and kinetics of the related parts such as the hip and ankle. In addition, muscle activity should be investigated to obtain the neuromuscular control ability of the dancers.

## Acknowledgements

This work was supported by the Mahidol University (NDFR07/2563). The authors would like to thank Ms. Zin Wai Htet and Mr. Krit Sangsuriyachaya for their contributions to the data collection process, as well as Mr. Nattaporn Intawachirarat for his assistance with the technological software system. We also would like to thank all participants who participated in the study.

## References

- [1] Elpidoforou M. Types of dance: steps and positions. In: Angoules A, editor. Overuse injuries in dancers. OMICS Group; 2016. p. 1-9.
- [2] Wilson M, Kwon YH. The role of biomechanics in understanding dance movement: a review. *J Dance Med Sci.* 2008; 12(3): 109-16.
- [3] Wilson M. Applying biomechanic research in the dance studio. *IADMS Bulletin for Teachers.* 2009; 1(2): 11-3.
- [4] Malkogeorgos A, Mavrovouniotis F, Zaggelidis G, Ciucurel C. Common dance related musculoskeletal injuries. *J Physic Educ Sport.* 2011; 11(3): 259-66.
- [5] Smith PJ, Gerrie BJ, Varner KE, McCulloch PC, Lintner DM, Harris JD. Incidence and prevalence of musculoskeletal injury in ballet: a systematic review. *Orthop J Sports Med.* 2015; 3(7): 2325967115592621. doi: 10.1177/2325967115592621
- [6] Caine D, Bergeron G, Goodwin BJ, Thomas J, Caine CG, Steinfeld S, et al. A survey of injuries affecting pre-professional ballet dancers. *J Dance Med Sci.* 2016; 20(3): 115-26. doi: 10.12678/1089-313X.20.3.115
- [7] Keeler CE. Access to health care among dancers. *Phys Med Rehabil Clin N Am.* 2021; 32(1): 21-33. doi: 10.1016/j.pmr.2020.08.004
- [8] Riding McCabe T, Ambegaonkar JP, Redding E, Wyon M. Fit to dance survey: a comparison with dancesport injuries. *Med Probl Perform Art.* 2014; 29(2): 102-10. doi: 10.21091/mppa.2014.2021
- [9] van Winden D, van Rijn RM, Richardson A,

- Savelsbergh GJP, Oudejans RRD, Stubbe JH. Detailed injury epidemiology in contemporary dance: a 1-year prospective study of 134 students. *BMJ Open Sport Exerc Med.* 2019; 5(1): e000453. doi: 10.1136/bmjsem-2018-000453
- [10] Krityakiarana W, Thippawan C, Nattanicha C, Jullumjiak P. Prevalence of musculoskeletal injuries in Thai classical dancers. *Research in Dance Education.* 2022: 1-15. doi: 10.1080/14647893.2022.2115993
- [11] Khonsalachelimkrung. [cited 2020 Sept 12]. Available from: <https://sites.google.com/site/khonsalachelimkrung/prawati>
- [12] Ministry of Culture. The royal "Khon" in celebration. Bangkok: Ministry of Culture; 2015.
- [13] ThaiHealth official. "Khon movement" Thai art "Healthy". [cited 2021 Feb 20]. Available from: <https://www.thaihealth.or.th/?p=240988>
- [14] Sritham P. The foundation practice of Khon: the benefits of preparing for Khon performer. [cited 2020 Sep 19]. Available from: [https://journalrdi.ubru.ac.th/article\\_files/A1546976690.pdf](https://journalrdi.ubru.ac.th/article_files/A1546976690.pdf)
- [15] Chansuwan S. Thai traditional choreography: differences between the male character of Khon and Lakhon dance. *SPAFA Journal.* 2005; 15(2): 45-54.
- [16] Thongkhamasuk P. Dance movement in monkey style in Khon. *Journal of the Royal Institute of Thailand.* 2012; 37(2): 218-35.
- [17] Negus V, Hopper D, Briffa NK. Associations between turnout and lower extremity injuries in classical ballet dancers. *J Orthop Sports Phys Ther.* 2005; 35(5): 307-18. doi: 10.2519/jospt.2005.35.5.307
- [18] Han S, Ge S, Liu H, Liu R. Alterations in three-dimensional knee kinematics and kinetics during neutral, squeeze and outward squat. *J Hum Kinet.* 2013; 39: 59-66. doi: 10.2478/hukin-2013-0068
- [19] Gontijo KN, Candotti CT, Feijó G, Ribeiro LP, Loss JF. Kinematic evaluation of the classical ballet step "plié". *J Dance Med Sci.* 2015; 19(2): 70-6. doi: 10.12678/1089-313x.19.2.70
- [20] Peng HT, Chen WC, Kernozek TW, Kim K, Song CY. Influences of Patellofemoral Pain and Fatigue in Female Dancers during Ballet Jump-Landing. *Int J Sports Med.* 2015; 36(9): 747-53. doi: 10.1055/s-0035-1547220
- [21] Whiting WC, Zernicke RF. Biomechanics of musculoskeletal injury. 2nd ed. Champaign: Human kinetics; 2008.
- [22] Thompson DM. Biomechanics of the knee. [cited 2022 Jan 7]. Available from: <https://ouhsc.edu/bserdac/dthompsoweb/namics/kneeak.htm#tibint>
- [23] Mesfar W, Shirazi-Adl A. Knee joint biomechanics in open-kinetic-chain flexion exercises. *Clin Biomech.* 2008; 23(4): 477-82. doi: 10.1016/j.clinbiomech.2007.11.016
- [24] Fotaki A, Triantafyllou A, Papagiannis G, Stasi S, Georgios P, Olga S, et al. The science of biomechanics can promote dancers' injury prevention strategies. *Phys Ther Rev.* 2021; 26(2): 94-101. doi: 10.1080/10833196.2020.1832707
- [25] Ameer MA, Muaidi QI. Influence of increasing knee flexion angle on knee-ankle varus stress during single-leg jump landing. *J Taibah Univ Med Sci.* 2017; 12(6): 497-503. doi: 10.1016/j.jtumed.2017.06.001
- [26] Chang M, O'Dwyer N, Adams R, Cobley S, Lee KY, Halaki M. Whole-body kinematics and coordination in a complex dance sequence: Differences across skill levels. *Hum Mov Sci.* 2020; 69: 102564. doi: 10.1016/j.humov.2019.102564
- [27] Walsh MS, Ford KR, Bangen KJ, Myer GD, Hewett TE. The validation of a portable force plate for measuring force-time data during jumping and landing tasks. *J Strength Cond Res.* 2006; 20(4): 730-4. doi: 10.1519/r-18225.1
- [28] Bouillod A, Costes A, Soto-Romero G, Brunet E, Grappe F. Validity and reliability of the 3D motion analyzer in comparison with the Vicon device for biomechanical pedalling analysis. *I C Sports Sci Res Tech.* 2016; 4: 63-6.
- [29] Molina-Rueda F, Fernández-González P, Cuesta-Gómez A, Koutsou A, Carratalá-Tejada M, Miangolarra-Page JC. Test-retest reliability of a conventional gait model for registering joint angles during initial contact and toe-off in healthy subjects. *Int J Environ Res Public Health.* 2021; 18(3): 1343. doi: 10.3390/ijerph18031343
- [30] Suntharanont R, Suntharanont K. Khon thai dance practicing. [cited 2021 Feb 14]. Available from: <https://youtu.be/IN4eNaKZrkE>
- [31] Schomacher J. The convex-concave rule and the lever law. *Manual therapy.* 2009; 14(5): 579-82. doi: 10.1016/j.math.2009.01.005
- [32] Wilson DR, Feikes JD, Zavatsky AB, O'Connor JJ. The components of passive knee movement are coupled to flexion angle. *J Biomech.* 2000;

- 33(4): 465-73. doi: 10.1016/s0021-9290(99)00206-7
- [33] Lin CW, Chen SJ, Su FC, Wu HW, Lin CF. Differences of ballet turns (pirouette) performance between experienced and novice ballet dancers. *Res Q Exerc Sport*. 2014; 85(3): 330-40. doi: 10.1080/02701367.2014.930088
- [34] Granata KP, Padua DA, Wilson SE. Gender differences in active musculoskeletal stiffness. Part II. Quantification of leg stiffness during functional hopping tasks. *J Electromyogr Kinesiol*. 2002; 12(2): 127-35. doi: 10.1016/s1050-6411(02)00003-2
- [35] Long KL, Milidonis MK, Wildermuth VL, Kruse AN, Parham UT. The impact of dance-specific neuromuscular conditioning and injury prevention training on motor control, stability, balance, function and injury in professional ballet dancers: a mixed-methods quasi-experimental study. *Int J Sports Phys Ther*. 2021; 16(2): 404-17. doi: 10.26603/001c.21150
- [36] Suhara H, Ae K, Nariai M, Shiraki H, Miyakawa S. A three-dimensional biomechanical analysis of KOSHIWARI exercis. *J Sport Sci*. 2018; 6: 149-58. doi: 10.17265/2332-7839/2018.03.00
- [37] Lorenzetti S, Gulay T, Stoop M, List R, Gerber H, Schellenberg F, et al. Comparison of the angles and corresponding moments in the knee and hip during restricted and unrestricted squats. *J Strength Cond Res*. 2012; 26(10): 2829-36. doi: 10.1519/JSC.0b013e318267918b
- [38] Shippen J. Turnout is an euler angle. *App Arts Biomech*. 2013: 73-83.
- [39] Turner C, Crow S, Crowther T, Keating B, Saupan T, Pyfer J, et al. Preventing non-contact ACL injuries in female athletes: What can we learn from dancers? *Phys Ther Sport*. 2018; 31: 1-8. doi: 10.1016/j.ptsp.2017.12.002
- [40] Masouros SD, Bull AMJ, Amis AA. (i) Biomechanics of the knee joint. *Orthop Trauma*. 2010; 24(2): 84-91. doi: 10.1016/j.mporth.2010.03.005
- [41] Ward RE, Fong Yan A, Orishimo KF, Kremenec IJ, Hagins M, Liederbach M, et al. Comparison of lower limb stiffness between male and female dancers and athletes during drop jump landings. *Scand J Med Sci Sports*. 2019; 29(1): 71-81. doi: 10.1111/sms.13309
- [42] Azevedo AM, Oliveira R, Vaz JR, Cortes N. Professional dancers distinct biomechanical pattern during multidirectional landings. *Med Sci Sports Exerc*. 2019; 51(3): 539-47. doi: 10.1249/mss.0000000000001817
- [43] Sharma L, Song J, Felson DT, Cahue S, Shamiyeh E, Dunlop DD. The role of knee alignment in disease progression and functional decline in knee osteoarthritis. *JAMA*. 2001; 286(2): 188-95. doi: 10.1001/jama.286.2.188
- [44] Yang NH, Nayeb-Hashemi H, Canavan PK, Vaziri A. Effect of frontal plane tibiofemoral angle on the stress and strain at the knee cartilage during the stance phase of gait. *J Orthop Res*. 2010; 28(12): 1539-47. doi: 10.1002/jor.21174
- [45] van de Pol GJ, Arnold MP, Verdonshot N, van Kampen A. Varus alignment leads to increased forces in the anterior cruciate ligament. *Am J Sports Med*. 2009; 37(3): 481-7. doi: 10.1177/0363546508326715
- [46] Kachanathu SJ, Kaur H, Natho M, Nuhman S. The effect of open and closed kinematics chain exercises in the management of meniscal injuries. *J Sci Innov Res*. 2013; 2(5): 927-31.
- [47] Harwood A, Campbell A, Hendry D, Ng L, Wild CY. Differences in lower limb biomechanics between ballet dancers and non-dancers during functional landing tasks. *Phys Ther Sport*. 2018; 32: 180-6. doi: 10.1016/j.ptsp.2018.05.005
- [48] Lorenzetti S, Ostermann M, Zeidler F, Zimmer P, Jentsch L, List R, et al. How to squat? Effects of various stance widths, foot placement angles and level of experience on knee, hip and trunk motion and loading. *BMC Sports Sci Med Rehabil*. 2018; 10: 14. doi: 10.1186/s13102-018-0103-7
- [49] Stand and stability. [cited 2022 Sep 8]. Available from: [http://www.cq.com.pl/publikacje/cqstabosc\\_art4.pdf](http://www.cq.com.pl/publikacje/cqstabosc_art4.pdf)
- [50] Ivanenko Y, Gurfinkel VS. Human postural control. *Front Neurosci*. 2018; 12: 171. doi: 10.3389/fnins.2018.00171
- [51] Neumann DA. *Kinesiology of the musculoskeletal system: foundation for rehabilitation*. 3<sup>rd</sup> ed. Milwaukee: Elsevier; 2017.
- [52] Bronner S, Ojofeitimi S. Gender and limb differences in healthy elite dancers: passe kinematics. *J Mot Behav*. 2006; 38(1): 71-9. doi: 10.3200/JMBR.38.1.71-79
- [53] Blazkiewicz M. Joint loads and muscle force distribution during classical and jazz pirouettes. *Acta Bioeng Biomech*. 2021; 23(1): 3-13.

- [54] Wan B, Shan G. Biomechanical modeling as a practical tool for predicting injury risk related to repetitive muscle lengthening during learning and training of human complex motor skills. Springerplus. 2016; 5: 441. doi: 10.1186/s40064-016-2067-y

# Endotracheal Intubation in Patients with COVID-19 in Priest Hospital during COVID-19 Pandemic: A Retrospective Study

Watchari Toni \*

Department of Anesthesiology, Priest Hospital, Thailand

## Abstract

**Background:** Coronavirus disease 2019 (COVID-19) is a new respiratory tract infection. In Thailand, it was first recognized on 12 Jan 2021. At Priest hospital the first patient was identified on 17 March 2021. While most patients with COVID-19 have no or mild symptoms, severe cases develop acute respiratory failure and need endotracheal tube intubation, including patients who need general anesthesia for surgery. We aimed to collect information of COVID-19 patients with endotracheal tube intubation included demographic patient data, techniques of intubation, complications after intubation and prevalence of COVID-19 associated infection to health care personnel performing intubation.

**Method:** A retrospective study of all COVID-19 patients admitted and underwent endotracheal tube intubation in Priest Hospital between 1 January 2021 and 31 December 2021 were performed. Doctors and nurse anesthetists were intubation teams. They observed for symptoms of COVID-19 infection and they tested COVID-19 antigen test kit every week.

**Results:** There was a total of 752 COVID-19 patients with confirmed Severe Acute Respiratory Syndrome-Cononavirus-2 (SARS-CoV-2) infection by real time polymerase chain reaction (RT-PCR) admitted from January 1 to December 31, 2021. Of these, a total of 14 COVID-19 patients needed intubation. 13 patients were intubated due to acute respiratory failure and 1 patient was intubated for general anesthesia. All of the patients were male because they were monks. Endotracheal intubations were performed in a negative pressure isolation room or isolation room. The help care personnel used full personal protective equipment (PPE) in all cases. At minimum, the full PPE included a respirator with a rating of N95 or higher, gowns, gloves and eye protection. We performed endotracheal tube intubation with the use of video laryngoscope and endotracheal tube stylet in all cases. There was one cause of failed intubation under video laryngoscope, but the performer accomplished successful intubation using Macintosh laryngoscope. Six patients received hypnotic drugs and neuromuscular blocking agents for rapid sequence induction. Two patients received only sedative drugs for intubation and 6 patients did not receive any drug for intubation. After intubation, only one patient significantly showed desaturation. In total, 9 help care personnel were intubation teams (4 doctors and 5 nurse anesthetists). None of them was infected with COVID-19 within 2 weeks after performing this procedure.

**Conclusion:** In severe cases, patients with COVID-19 infection may develop acute respiratory failure which need endotracheal tube intubation. Endotracheal tube intubation in patients with COVID-19 poses a risk of infection for the health care personnel involved in the procedure. In this study none among the personnel performing intubation was infected with COVID-19. The results suggest that, full personal protective equipment, video laryngoscopy, skills with multiple intubation techniques and proper medications were important components for patients and health care personnel's safety.

**Keywords:** COVID-19, Priest, Intubation, Acute respiratory failure

---

\* Corresponding author.

E-mail address: watcharitoni@gmail.com (Watchari Toni)

## 1. Introduction

Coronavirus disease 2019 (COVID-19) is a new respiratory tract infection. In Thailand, it was first recognized on 12 Jan 2021. While most patients with COVID-19 have no or mild symptoms, severe cases developed acute respiratory failure and need endotracheal tube intubation, including patients who need general anesthesia for surgery. Among persons infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus that causes COVID-19, approximately 8% will require endotracheal intubation and mechanical ventilation [1]. Prior studies examining health care workers diagnosed with the 2003 severe acute respiratory syndrome (SARS), identified intubation and bag-mask ventilation as possible sources of aerosol generation. In meta-analysis examining SARS in health care workers, those performing tracheal intubation had an odds ratio for developing SARS of 6.6 in comparison to those health care providers who did not perform this procedure [2]. We collected data from COVID-19 patients in a Priest hospital in Bangkok to investigate demographic data, intubation techniques, complications after intubation and prevalence of COVID-19 infection in health care providers performing intubations.

## 2. Methods

The study protocol was approved by the Priest Hospital Ethics Committee. A retrospective study of all COVID-19 patients admitted and who underwent endotracheal tube intubation in the study Priest Hospital between 1 January 2021 and 31 December 2021 was conducted. The diagnosis of COVID-19 was made according to the WHO interim guidance [3]. Laboratory confirmation of SARS-CoV-2 was defined as a positive result of real-time reverse transcriptase polymerase chain reaction (RT-PCR) assay of naso-pharyngeal swabs. Prior Thai study collected data about endotracheal tube intubation in COVID-19 patients over a short period [4]. Information of COVID-19 cases with endotracheal intubation included demographic data, rate of required intubation, types of room for intubation, types of oxygen supplement before intubation,

oxygen saturation before intubation, source of oxygen for pre oxygenation, devices for intubation, technique of drug used for intubation and acute complications after intubation. Descriptive statistics was used to summarize the characteristics of the participants. Doctors and nurse anesthetists were the members of intubation teams. They self-observed for symptoms of COVID – 19 infection and were tested with COVID-19 antigen test kits every week.

## 3. Results

There were 752 COVID-19 patients with confirmed SARS-CoV-2 infection by real time polymerase chain reaction (RT-PCR) admitted from January 1 to December 31, 2021. Of these, a total of 14 COVID-19 patients needed intubation. Thirteen patients were intubated due to acute respiratory failure and 1 patient was intubated for general anesthesia. The patients' characteristic and underlying diseases are described in Table 1. All of the patients were male because they were monks. Four patients (28.6 %) were 20-60 years old, 3 patients (21.4 %) were 60-70 years old, and 7 patients (50%) were more 70 years old. The mean age was 67.3 years old. The eldest patient was 96 years old and the youngest 40. Of 14 patients, only one patient was normal weight, 3 patients (21.4 %) were overweight (having a body mass index of 23-24.9), 6 patients (42.9 %) were level 1 obese (BMI of 25-29.9), and 4 patients (28.6 %) were level 2 obese (BMI of 30 or more). All of patients had underlying diseases, most commonly obesity, diabetes mellitus and hypertension in this order. Endotracheal intubation was performed in a negative pressure isolation room for 13 patients (92.9 %) and 1 patient (2.1 %) was intubated in isolation room for general anesthesia and surgery. After surgery, the room was cleaned and disinfected immediately.

Clinical characteristics before and after intubation are presented in Table 2. Most of the patients had high flow nasal cannula for supplemental oxygen therapy before intubation. There were 6 patients (12.9 %) with mild desaturation. 5 patients (35.7 %) with moderate desaturation and 3 patients (21.5 %) with

Table 1. Demographic data and medical characteristics of intubated COVID-19 patients

	Count	Ratio
<b>Gender</b>		
Male	14	100 %
Female	0	0 %
<b>Age (year)</b>		
0 – 19	0	0 %
20 – 60	4	28.57 %
60 – 70	3	21.43 %
> 70	7	50 %
<b>BMI (kg / m<sup>2</sup>) WHO Asian-BMI classification</b>		
< 18.5 (underweight)	0	0 %
18.5 – 22.5 (normal weight)	1	7.14 %
23 – 24.9 (over weight)	3	21.43 %
25 – 29.9 (level 1 obesity)	6	42.86 %
> 30 (level 2 obesity)	4	28.5 %
<b>Underlying disease</b>		
Diabetes mellitus	10	71.43 %
Hypertension	8	57.14 %
Coronary artery disease	2	14.23 %
Dyslipidemia	3	21.43 %
Chronic kidney disease	3	21.43 %
Hepatic failure	1	7.14 %

Table 2. Clinical characteristic before and after intubation

	Count	Ratio
<b>Oxygen support before intubation</b>		
Oxygen cannula	1	7.14 %
Oxygen mask with reservoir bag	1	7.14 %
High flow nasal cannula	12	85.71 %
<b>Oxygen saturation before intubation</b>		
Mild desaturation (90 -95 %)	6	42.85 %
Moderate desaturation (80 -85 %)	5	35.71 %
Severe desaturation (< 80 %)	3	21.43 %
<b>Pre oxygenation</b>		
Self inflating bag and reservoir bag	13	92.86 %
Anesthetic circuit with mask	1	7.14 %
<b>Devices used for intubation</b>		
Disposable <i>Glidescope</i>	13	92.86 %
Macintosh direct laryngoscope	1	7.14 %
<b>Drugs used far intubation</b>		
None	6	42.86 %
Sedative drugs (propofol, diazepam)	2	14.29 %
Hypnotic drugs and neuromuscular blocking agents (propofol, succinylcholine)	6	42.86 %
<b>Difficulty intubation</b>		
Yes	1	7.14 %
No	13	92.86 %
<b>Complication</b>		
Severe desaturation (marked decreased from before intubation)	1	7.14 %
None	13	92.86 %

severe desaturation. Most of the patients on supplemental oxygen were ventilated using self-inflating bag with reservoir bag for pre-oxygenation. Only one patient received anesthesia circuit with face mask (not positive pressure ventilation) for pre-oxygenation. All cases used bag mask with high-efficiency particulate air (HEPA) filter. We used videolaryngoscope and endotracheal tube stylet for every intubation. One patient could not be intubated under videolaryngoscope, but the performer accomplished successful intubation using Macintosh laryngoscope. All patients had some degree of desaturation before intubation. After intubation most of the patients had oxygen saturation similar to before intubation and after mechanical ventilation oxygen saturation was increased. Only one patient had temporary decreased oxygen saturation from 80% to 40-50% due to difficult intubation. None of patient need tracheostomy or emergency airway procedure.

The intubation teams included 9 health care personnel (4 doctors and 5 nurse anesthetists). They self-observed for symptoms of COVID-19 infection and they were tested with COVID-19 antigen test kits every week. None of them was infected with COVID-19 within 2 weeks after performing this procedure.

#### 4. Discussion

In 2021 during the COVID-19 pandemic, the Priest Hospital in this study admitted 752 COVID-19 patients of these 14 COVID-19 patients (1.9%) needed intubation. All of them had underlying diseases. In this study, almost all cases received the intubation in a negative pressure isolation room [5-7], except one case who was intubated in isolation room (normal pressure) for general anesthesia because at the time the operation rooms were normal pressure ones. Recently, the COVID-19 pandemic highlighted the potential utility of video laryngoscopy to both reduce difficult intubation with its associated complications and reduce intubation provider contamination [5, 6]. We found that, critically ill patients with COVID-19 were desaturated at the time of endotracheal tube intubation. There were 8 of 14 patients moderate

to severe desaturated. Therefore, we used sedative drug or neuromuscular blocking for intubation in these patients to reduce the risk of severe hypoxemia during and after intubation. In this study the health care personnel used full personal protective equipment (PPE) that included a respirator with a rating of N95 or higher, gowns, gloves and eye protection and doffing the full PPE in anteroom [5, 6]. After doffing, the proceduralists washed body and hair [5, 6]. In our study, none of 9 health care personnel in the intubation teams (4 doctors and 5 nurse anesthetists) was infected with COVID-19 within 2 weeks after performing this procedure. The novel coronavirus imposes an increased risk for aerosol borne transmission of viral particles to personnel performing endotracheal intubation. COVID-19 is predominantly transmitted through droplet, aerosol and fomite but this study did not find COVID-19 infections among intubators and assistants. The limitation of this study was that if the intubation teams were infected with COVID-19 within 2 weeks after performing the procedure, they may have been infected from other sources since they live in endemic area of COVID-19 disease.

#### 5. Conclusion

In severe cases, patients with COVID-19 infection may develop acute respiratory failure and need endotracheal intubation. Endotracheal intubation in patients with COVID-19 poses a risk of infection for the health care personnel involved in the procedure. In this study no personnel was infected with COVID-19 after performing intubation. The results suggest that, full personal protective equipment, video laryngoscopy, skills with multiple intubation techniques and proper medications were important components for patients and health care personnel's safety.

#### References

- [1] Grasselli G, Zangrillo A, Zanella A, Antonelli M, Cabrini L, Castelli A, et al. Baseline characteristics and outcomes of 1591 patients infected with SARS-CoV-2 admitted to ICUs of the Lombardy Region, Italy. *JAMA*. 2020;

- 323(16): 1574-81. doi: 10.1001/jama.2020.5394
- [2] Tran K, Cimon K, Severn M, Pessoa-Silva CL, Conly J. Aerosol generating procedures and risk of transmission of acute respiratory infections to healthcare workers: a systematic review. *PLoS One*. 2012; 7(4): e35797. doi: 10.1371/journal.pone.0035797
- [3] World Health Organization [WHO]. Clinical management of severe acute respiratory infection (SARI) when COVID-19 disease is suspected. [cited 2020 May 29]. Available from: [https://www.who.int/publications-detail/clinical-management-of-severe-acute-respiratory-infection-when-novel-coronavirus-\(ncov\)-infection-is-suspected](https://www.who.int/publications-detail/clinical-management-of-severe-acute-respiratory-infection-when-novel-coronavirus-(ncov)-infection-is-suspected).
- [4] Injampa S, Kimpee P, Luetrakool P, Narritsirikul C, Morakul S, Pisitsak C, et al. Experiences of tracheal intubations by anesthesiologists in patient with COVID-19. *Thai J Anesthesiol*. 2020; 46(3) supplement: 1-7.
- [5] Cheung JC, Ho LT, Cheng JV, Cham EYK, Lam KN. Staff safety during emergency airway management for COVID-19 in Hong Kong. *Lancet Respir Med*. 2020; 8(4): e19. doi: 10.1016/S2213-2600(20)30084-9
- [6] Cook TM, El-Boghdadly K, McGuire B, McNarry AF, Patel A, Higgs A. Consensus guidelines for managing the airway in patients with COVID-19: Guidelines from the Difficult Airway Society, the Association of Anaesthetists, the Intensive Care Society, the Faculty of Intensive Care Medicine and the Royal College of Anaesthetists. *Anaesthesia*. 2020; 75(6): 785-99. doi: 10.1111/anae.15054
- [7] El-Boghdadly K, Wong DJN, Owen R, Neuman MD, Pocock S, Carlisle JB, et al. Risks to healthcare workers following tracheal intubation of patients with COVID-19: a prospective international multicentre cohort study. *Anaesthesia*. 2020; 75(11): 1437-47. doi: 10.1111/anae.15170

# How COVID-19 Pandemic Affects Women's Fertility and Cross-Border Reproductive Care: A Taiwanese-Based Review

Sun Chia-Ting \*

Graduate Institute for Social Research and Cultural Studies, National Chiao Tung University, Hsinchu, Taiwan; The Center for Teacher Education, National Taiwan Sport University, Taoyuan, Taiwan

## Abstract

**Background:** The purpose of this short experience-based paper is to compare and discuss the state of cross-border reproductive care (CBRC) before and after the outbreak, and to point out the possible impact of the COVID-19 pandemic on women who rely on cross-border treatment. In the context of modernity, international commercial sperm banks and CBRC have emerged as social and political solutions for single women and lesbians to overcome reproductive dilemmas and build families. However, with the spread of COVID-19 and the mobility difficulties caused by strict border control, this phase-based solution to social infertility seems to be examined again.

**Method:** This paper adopts a textual analysis method to analyze the social meanings of official border policy texts and artificial reproduction recommendations in various countries. And 20 members were randomly interviewed from five Facebook communities related to sperm banking and CBRC. Also, as a complete observer, the websites of Facebook communities, sperm banks, and hospitals providing reproductive care were observed to map changes in medical mobility as a result of the COVID-19 pandemic.

**Results:** There is a lack of research on the impact of COVID-19 on cross-border mobility and encounters with social infertility due to medical factors. It also motivates us to reflect on the specific social conditions, regulations and cultures in different national contexts, and to think about the reasons that drive people to adopt CBRC, as well as the factors that contribute to the social infertility and reproductive resource scarcity.

**Conclusion:** This article believes that reproductive regulations will eventually need to be revised to make them more relevant and humane after the urgent epidemic and national security governance. During the ongoing COVID-19 pandemic, these basic and important questions reappear before our eyes, and they are testing how individuals and the public make judgments and decisions in the face of the COVID-19.

**Keywords:** Border, COVID-19, Dilemma, Fertility, Reproductive care

## 1. Introduction

This article is concerned about the status of CBRC in the context of modernity. Even though this paper uses COVID-19 as an important event to divide the different cycles, it is worth noting that the development of CBRC is not entirely dualistic, but constantly evolving with the current social events. However, COVID-19 does bring us some points of observation. For certain generations, the declining fertility rate and women's

reproductive choices have become issues of public concern. The development of artificially assisted reproductive technology shows the evolution of technology and social culture. The reproductive market has become a business with a huge output value. The networks and the institutions which support people to reach the goal of reproductive independence can be regarded as products of modernity. I have tried to ascertain the role and influence of the international sperm

---

\* Corresponding author.

E-mail address: tinnalovefriend@yahoo.com.tw (Sun Chia-Ting)

banks and CBRC in my doctoral dissertation [1] and aim to promote women's reproductive rights in Asia as well as to problematize and re-examine them in contemporary society. The research period was from 2016 to 2020.

The results indicated that both of them have had a wide impact in the past three decades on women's fertility. However, the public holds different opinions on the issues, and related studies are not evenly distributed. My research believes that they are, on the one hand, an important staged solution to support women's access to fertility, which has promoted the birth of new types of families and new types of motherhood, but at the same time they also bring about the issues of ethics and risk governance and other aspects of the debate, urging the general public to respond in a local context through discussion or policy modification.

They have become a common strategy for single women and lesbians to pursue reproductive autonomy and build families. For Taiwan or even Asia, our view of this phenomenon is still somewhat different from that of northern Europe and North America where sperm banks are popular. We don't have many studies on it so far, our society is being deeply affected by it due to factors such as globalization, technological development and consumer society. As a symbol and a product of the modernity of artificially assisted reproduction, international commercial sperm banks and CBRC can be used as a representation of the changes in contemporary society and direct us on a path to reflect on changes in our cultural and social conditions.

Because I am concerned with the life situations of socially infertile women, I wanted to reflect on the current conditions of reproductive practices in Asia, so for this research I participated in the visiting program at Yale Interdisciplinary Center for Bioethics and The Hastings Center, about three years ago. I also went to Thailand, China, Europe, Japan, and other countries for field research and data collection with some government funding. One of my related studies has won the *PhD. Thesis Award of the Population Association of Taiwan* in 2021. With the current trend of sub-replacement fertility

in many countries, this is an indication of the importance and the possible contribution of this topic. At the same time, however, it is necessary to conduct more comparative studies in different countries. In particular, this study believes that sperm banks and networks of international treatment not only provide reproductive materials and connections, but also influence people's views on gender, family, and self, as well as the development of contemporary social relations and the process of family construction.

Here I would like to quickly provide some background information about the commercial sperm industry and CBRC. As we know, there are many different ways to obtain sperm resources, including government sperm banks, government-commissioned hospital sperm banks, commercial sperm banks, various forms of gray markets, and individual donors, each with different characteristics, advantages and limitations, and their own clients. For example, government sperm banks may have a shortage of sperm resources and users may have to wait longer, while commercial sperm banks may be profit-oriented and ignore ethical or governance issues. However, due to the development of the consumer society, commercial sperm banks have become a major supplier of sperm resources. The sperm industry began to develop a long time ago and became visible around 1980 due to rapid changes in the global situation. Subsequently, through the establishment of a large number of sperm banks, the consolidation of large companies and the expansion of global businesses, the global sperm industry has reached a value of US\$4-5 billion by 2020.

CBRC for the purpose of obtaining reproductive resources or treatments has been one of the main items in the development of medical tourism in many countries. Different biobanks target different populations, and the CBRC linked to them also has different routes. In addition to the regional travel within Europe, for example, sperm banks are most developed in North America and Northern Europe, so many people also travel to the United States and Denmark to get sperm resources. However, they have also established resource transportation networks with clinics or

small sperm banks around the world to allow users to plan for a more convenient trip. Anyway, CBRC appeals to socially infertile clients everywhere who are limited by the legal, cultural or social structures of their home countries. Europe has a long-standing history of cross-border healthcare. The European Union lends itself well to cooperative healthcare through its culture, history, and geography. During the COVID-19 crisis, Europe's cooperative approach has continued, while in North America isolationism has prevailed [2].

Broadly speaking, CBRC has become an important approach to accessing reproductive resources and treatment in the contemporary era, and a strategy to overcome the reproductive dilemma of socially infertile individuals. The occurrence of COVID-19 has affected global health care capacity and boundary control policies, and has changed the current status of CBRC, yet there is no research related to this issue. Therefore, this paper proposes a research question: What is the impact of COVID-19 on CBRC and women's reproductive practices?

This paper has two objectives, which also demonstrate its importance. The first is to complement the existing studies by adding an Asian perspective to strengthen the cross-regional perspective of this issue, so that future studies can better analyze this global situation. Second, although there are many studies on how COVID-19 affects health and public health governance, there is still a lack of research on the effects of COVID-19 on women's fertility [3] and the fertility dilemmas that women experience during COVID-19. Therefore, based on this basis, this paper is intended to serve as a reference for exploring the current state of women's reproductive practices and to contribute to the formulation of current public health, health care, and border policies.

## 2. Methods

This paper is a qualitative study, the purpose of this short experience-based paper is to compare and discuss the state of CBRC before and after the outbreak, and to point out the possible impact of the COVID-19 pandemic on

women who rely on cross-border treatment. The analysis begins with an introduction that briefly presents some of the findings from my doctoral dissertation. It then critically reflects on the overall phenomenon during the COVID-19 pandemic, based on research and interviews from 2020 to 2022. The main methods and materials of this study are as follows. First, a text analysis method was used to analyze the social meanings of official border policy texts and artificial reproduction recommendations of various countries, with particular attention to the United States and Northern Europe, where sperm banking and CBRC are highly popular.

The materials were collected by searching for key words such as COVID-19, fertility, reproductive medicine, guidelines, and border policy. Among them, the fertility-related unofficial guidelines announced by the American Society for Reproductive Medicine (ASRM) and the European Society of Human Reproduction and Embryology (ESHRE) have a strong influence on CBRC. Information was mainly obtained from the official websites of the Ministry of Health and other agencies. Second, from Facebook communities related to sperm banking and CBRC, I picked five of them with more than 3,000 members representing diverse backgrounds and posted on the Facebook site to publicly ask members about their experiences with the COVID-19 and to announce the call for random respondents. I interviewed 20 voluntary donors, users, and administrators of various nationalities, 30 to 45 years of age. All information was anonymous, and each conversation lasted about an hour, mostly in English via Facebook messages. The discussions were open-ended and focused on their experiences with CBRC, their fertility dilemmas after encountering COVID-19 pandemic, and adjustments to their original fertility plans and practices. At the same time, I have also observed the variability of medical mobility due to the COVID-19 pandemic as a complete observer in the Facebook communities, the websites of sperm banks and hospitals providing reproductive treatments, and everyday life.

### 3. Results

#### 3.1. *Images of reproductive practices during COVID-19*

With regard to the impact of borderline policies under the COVID-19 pandemic, we are not just talking about the inability of people to travel abroad for CBRC or the inaccessibility of reproductive resources, but about the nature of the change: It is a change in the overall reproductive practice program, a change in the strategies and relationships between different actors in response to international conditions and reproductive markets, a change in ethics and value choices, and an opportunity to see that there is still room for progress in social policy.

An important element of CBRC is navigating the border and finding available resources and treatment between the gaps in the law across countries. Therefore, changes in border policy will have a significant impact on CBRC. The trends resulting from the border closures and transportation bans of the COVID-19 pandemic suggest that such travel is only a palliative solution, not a permanent one. In the packaging of free markets and the commercialization of fertility, we ignore the fact that the issue of reproductive rights has never been resolved. Border restrictions limit people's interactions, which means they are less likely to seek reproductive resources outwardly [4]. On the one hand, ASRM and ESHRE recommend that people limit their movements and minimize non-essential and non-urgent medical behaviors during the COVID-19 pandemic to avoid the risk of transmission and maintain medical capacity control [5]. Many women's reproductive programs are delayed because there are insufficient cases and studies demonstrating the impact of COVID-19 pandemic on fertility, and reproductive resources are more difficult to obtain. Some of them postponed their fertility plan because of the fear of future financial hardship, potential pregnancy risks, psychological stress and anxiety [3, 6, 7]. However, in Europe, for example, the proportion of abandoners is much higher in Italy than in other European countries. Different economic, demographic, and policy pre-crisis

background and post-crisis prospects may have had some impact on this result [8].

Border closures or strict controls have had a number of immediate effects that can be broken down into a holistic and individual analysis perspective or explored through the roles of user and donor. Briefly, the most common physical effects are a decrease in the number and stock of sperm donations, a lack of reproductive resources, and the inability of sperm to enter customs or for people to take CBRC or receive sperm across borders as they did in the past. Because of the delicate time planning and management involved in fertility planning, there are many uncontrollable factors or increased costs when people are unable to move or miss important time points due to COVID-19 pandemic [7]. Also, COVID-19 pandemic makes it challenging to confirm the quality of donor sperm and the health status of the donor.

In addition to personal responses, the entire donor-conceived community network responded in many ways, such as providing emotional support and encouragement, and sharing relevant information (medical knowledge, healthcare experiences and first-hand information, customs shipments, biobank processes, changes in medical procedures, funding updates, differences in donor selection and evaluation, etc.). They also guided community members to adopt different strategies during the COVID-19 pandemic, such as doing egg retrieval and shipping the eggs to another country for later IVF. But at the same time, the original problems of these communities have become more apparent. The user groups in a community determine the culture and status of the community, but many communities lack information about the culture of people from specific regions or backgrounds, such as Asia. In the process of interaction, users sometimes try to interpret the possible situations of other users through their own cultural perspectives, and this cultural gap from economic, cultural, and geographical factors is extremely large.

Commercial Sperm banks have their own marketing strategies in response to COVID-19 pandemic due to the need for continuing business operations. For example, they provide more

personalized assistance and interviews, increase marketing of additional genetic testing services, offer discounted donor sperm, extend the period of free sperm storage to encourage user motivation and customer retention. They also promote the leading role of sperm banking as a confidential, professional, scientific and secure service.

### *3.2. Boundary restrictions and time allocation*

Although CBRC has emerged as a social and political strategy for single women and lesbians to overcome their reproductive dilemmas and build families, this route of solving problems has changed since the COVID-19 pandemic. After I completed my PhD in 2021, the COVID-19 pandemic started to get worse. In the context of global travel restrictions and border closures, even countries in the Schengen area delayed their border-free policies, and global mobility has been forced to slow down or even stop. This has compelled us to re-examine the various social and economic conditions we take for granted. What we have to face is that this situation and its timing have brought us into a new world that is different from the past, affecting the global trade in reproductive resources, and access to reproductive travel to overcome legal and resource constraints. We must now return to our original perspective and face fundamental outstanding issues.

In this globalized generation, if you want to use third-party donor sperm to facilitate pregnancy, you can obtain sperm through private donations, national sperm banks, and commercial sperm banks [9, 10]. Because commercially donated sperm can be ordered via the Internet and delivered over a short timescale, and because there is a wide range of donation templates to choose from, it has quickly become an important method for receiving donor sperm. However, it should be emphasized that many countries may not allow the importing of reproductive resources such as sperm and eggs. This is based on different cultural backgrounds, religious beliefs, and legal provisions. Some countries may face a scarcity of local reproductive resources. Most commonly, the government does not allow people who do not belong to a heterosexual marriage to use assisted

reproductive technology and donor sperm. Therefore, people in need must travel to other countries to obtain commercially donated sperm and the required reproductive treatment [11].

On the one hand, CBRC appears to address some of the problems in a market-orientated manner. On the other hand, many countries consider reproductive rights to be a difficult issue that can easily arouse social opposition. So, these countries may choose to ignore the issues or rely on cross-border treatments too much in order to deal with their own legal amendments and social conditions. However, the trends resulting from the border closures and transportation bans of the COVID-19 pandemic suggest that such travel is only a palliative solution, not a permanent one. In the packaging of free markets and the commercialization of fertility, we ignore the fact that the issue of reproductive rights has never been resolved. Border restrictions limit people's interactions, which means they are less likely to seek reproductive resources outwardly. As can be seen, the law has a far greater impact on the use of donor sperm and CBRC than capital and wealth. This suggests that countries that do not yet broadly allow access to donor sperm and assisted reproductive technologies for diverse subjects need to address the most basic issues of legal revision to protect the fundamental rights of diverse subjects and demand reproductive justice.

The pace of the world has slowed as a result of COVID-19 pandemic and the best time for women to have children is being lost [6]. The American Society of Reproductive Medicine issued the first version of "Patient Management and Clinical Recommendations" [12] on 17 March 2020. This recommended that any unnecessary fertility treatment should be suspended for the following reasons: the inadequacy of existing COVID-19 research; any drugs developed may not be suitable for patients undergoing fertility treatment; optimizing medical human resources allocation; and avoiding close contact with people. Given the importance of timing for fertility, the current COVID-19 pandemic makes it necessary to suspend fertility planning, which is not fully and effectively controlled [4]. Therefore, information will be

updated every two weeks to help people grasp the timing of treatment. In the most recent information, it was mentioned that the “COVID-19 vaccination does not induce antibodies against the placenta”.

For females, timing is the key to reproductive success. When people have to stop their way of life, change their work and social patterns, or stay at home to manage their health, a woman’s physiology never stops ageing. One of the risks women face in such emergencies is that the timing of childbearing may be missed and is irreversible. At the same time, the current situation places greater emphasis on the status of the family as a basic social unit. It also forces us to look squarely at whether the definition and structure of the family have changed, as well as looking at assisted reproductive technology and third-party donor sperm, which are different ways from how families were established in the past.

Indeed, sperm banks have not stopped their global operations and people can still order donor sperm via the Internet. However, in addition to the national restrictions I mentioned earlier, due to the lack of a complete study of the COVID-19 pandemic, doubts about safety and donor sperm quality still exist and have become a test of risk management ability in the sperm market.

Due to strict regulations and cultural openness, Denmark is well known in the commercial sperm market. Denmark has amended the legislation around 2020 to improve the ethical concerns of donor-conceived families and to establish a ceiling on the number of conceptions. The new regulations state that all donor sperm must be sent to a medical institution or an address where medical staff are located, and the mode of receiving sperm from a private address is no longer accepted. Despite good intentions, the provision now highlights the restraints of the problem and the possible effects of moving again from home insemination to medicalization in a situation of restricted movement.

Medical institutions are now high-risk places to which people no longer have the mobility to cross borders or travel. Many donation arrangements have also been temporarily postponed or stopped, leaving a lack of sperm sources. Donors’ new

disease histories and varying degrees of self-management in the face of COVID-19 pandemic may also present different risk management and sperm quality issues. This approach to pregnancy, especially for single women and lesbians, which was initially used as a model solution, is now reversing and facing the same dilemma as it was decades ago.

I believe that the commercial donor sperm market and CBRC are temporary alternatives, but are still incomplete. They support multiple forms of family development, but at this time when COVID-19 pandemic is rampant, their impact has declined significantly, and multiple reproductive choices associated with capital no longer exist. As can be seen from this, the effect of the law on the use of donor sperm is far greater than that of capital and wealth. According to the establishment of the law, people and institutions that store donor sperm are further shaped by each other under the legal framework and form a complete network. Finally, capital and wealth play different roles.

#### **4. Discussion**

The COVID-19 pandemic poses a risk management challenge for female fertility, a time allocation and practice challenge, and an increased economic challenge, and has stimulated renewed public reflection on Taiwan’s reproductive and cellular regulation and social infertility, leading to a debate on the accessibility of reproductive resources and technology.

I started to think about the main theme of this paper based on Taiwan. Although there is still room for improvement in the governance and ethics of the sperm industry and CBRC, I also believe that CBRC is still a temporary solution to social infertility until the law in Taiwan allows single women and lesbians to have legal access to ART and reproductive resources. The outbreak of COVID-19 pandemic and its impact on CBRC has led me to reflect on why people do not have access to reproductive resources and technologies in Taiwan and some other countries? Can we provide more structured support for the reproductive practices of others who are not in heterosexual marriages?

One of the key tasks that the gender

movement has been actively promoting is the implementation of reproductive rights and the promotion of equality in access to artificially assisted reproductive technologies and reproductive resources for different populations. There are many studies on the impact of COVID-19 pandemic on reproductive health and public health, but there is a lack of research on the impact of COVID-19 pandemic on cross-border mobility and encounters with social infertility due to medical factors, and most studies have focused on Northern Europe and North America. However, different cultures and social norms have different effects on the formation of sperm banks and CBRC, and CBRC also has different pathways and destinations depending on its content, purpose, and price, and therefore may encounter varying conditions in terms of COVID-19 risk. In the future, field studies in other regions such as Asia, Africa, and Latin America should be developed as much as possible in order to create a multidimensional space for reference.

In addition to regulations, how sperm banks and CBRC respond to local policies is also an issue that requires attention. The adjustment of laws and changes in national regulations are often linked to public discussions on ethics and paternity, showing a dynamic process of mutual shaping, and implying that the actions of the public and government have a role to play in adjusting the reproductive consumer market, rather than all being dominated by market mechanisms. From the experience of the United States, Denmark, and other countries and regions, most of the amendments to reproductive laws have gone through a process of social mobilization and struggle between the pro and con sides, whether it is the universalization of access rights, the inclusion of reproductive expenditures in social welfare coverage, or the linkage to the legalization of diverse marriage and family.

Now the COVID-19 pandemic has become an unpredictable factor of change, and how countries regulate borderline, reproductive-related actions and CBRC in the context of the COVID-19 pandemic is not so much related to discussions of the declining birth rate as it is to policies that

maintain population security and public health. However, this paper argues that because of the impact of border closures on CBRC and women who consider it as a solution to social infertility, reproductive regulations will eventually need to be revised to make them more relevant and humane after the urgent epidemic and national security governance.

## 5. Conclusion

Starting from normative texts and daily observations, this paper attempts to outline the possible effects of the outbreak of COVID-19 pandemic on CBRC and the women who rely on it. This also leads us to think back to the factors that led people to adopt CBRC and reflect on the specific social conditions, regulations and cultures in different national contexts and, in particular, on the factors that contribute to social infertility and the scarcity of reproductive resources. How are reproductive rights and reproductive justice be implemented in today's precarious situation? How does the commercial sperm market negotiate business and ethical issues? How do individuals manage their fertility and autonomy? During the ongoing COVID-19 pandemic, these basic and important questions reappear before our eyes, and they are testing how individuals and the public make judgments and decisions in the face of the unknown.

Most of the literature cited in this paper, which focuses on different countries and regions, agrees that further research is needed. This paper suggests that Taiwan and other countries where social infertility still exists should take into account the current situation of local norms, social culture, and the overall development of the international medical network, and expeditiously make ART and reproductive resources available to all on an equal basis through appropriate legislative amendments and other actions, and include them in social welfare programs to encourage fertility, emphasize the rights of the increasing number of donor-conceived families, and provide corresponding economic and social support systems.

Modernity in reproduction marks a change in society. At a time when the COVID-19 pandemic

is a major global event, many issues requiring public consultation and discussion have returned to our horizon. This paper is limited by the fact that more in-depth empirical investigation has not yet been conducted and is still at a preliminary stage of analysis because of the COVID-19 pandemic has created restrictions on the mobility required to conduct research. The recent global trend of COVID-19 pandemic seems to be slowing down, and the development of CBRC and related public health governance policies in various countries has yet to be explored. I hope that this paper will help to enhance the public's understanding of this phenomenon and create a new space and resource for the discussion of this global issue in the public discourse, research, and practice in the future, and in turn, provide us with a feasible pathway to analyze the current situation of contemporary society and public health.

### Recommendations

In summary, this paper suggests that we should take seriously the reproductive dilemmas of women and their life experiences during COVID-19. It is important to understand the widespread barriers and psychological stress that COVID-19 has caused to cross-border reproductive care and women's reproductive programs. Regardless of whether donations and use of third-party donor sperm were allowed in the past, today, local governments should take the initiative to appropriately amend laws and set up supporting methods so that people can legally and appropriately donate and use sperm in their own countries, and establish efficient cooperative programs with sperm banks as needed to introduce and manage commercial donor sperm in response to the shortage of sperm sources or the sense of differentiation and reproductive deprivation due to differences in the capital of demanders.

Because of the lack of sperm sources in Taiwan and the global trend of reproductive consumption, it is bound to become a common issue for Taiwan in the future. Therefore, we need to consider a possible model of government-led cooperation with large reproductive resource organizations such as ICSB that is healthy, equal,

and ethical, in order to solve the current situation of lack of reproductive resources and to investigate the details and methods of governance. For example, we can make reference to the Danish regulations and registry. And those who need sperm can apply to the government for the use of donor sperm, and the government will compile and apply to ICSB for the importation of donor sperm. I believe this is not only a situation that Taiwan will face, but all countries should think about how to regulate and supervise it in the future. At the end, further research is also needed.

### Acknowledgments

The main body of this article comes from my doctoral dissertation. Yuan-Horng Chu is my supervisor, I am grateful for his patience and the intellectual inspiration he brought to me. The exploration of Asian societies in this article is partly derived from discussions with Marcia C. Inhorn and scholars I met during my academic visits to a joint program supported by Yale University and the Hastings Center. I appreciate their suggestions and concerns. I am also thankful to the faculty and friends of Chulalongkorn University for their assistance and hospitality during my numerous visits for conducting field research. Many women are still encountering fertility dilemmas, and I hope these words and future policies will stand by their side and offer more help and possibilities.

### References

- [1] Sun CT. The functions and social consequences of the international sperm bank as a modern institution. Taiwan: National Chiao Tung University; 2021.
- [2] Glass LT, Schlachta CM, Hawel JD, Elnahas AI, Alkhamesi NA. Cross-border healthcare: a review and applicability to North America during COVID-19. *Health Policy Open*. 2022; 3: 100064. doi: 10.1016/j.hpopen.2021.100064
- [3] Madjunkov M, Dviri M, Librach C. A comprehensive review of the impact of COVID-19 on human reproductive biology, assisted reproduction care and pregnancy: a Canadian perspective. *J Ovarian Res*. 2020; 13(1): 140. doi: 10.1186/s13048-020-00737-1
- [4] Tsakos E, Tsagias N, Stergioula A,

- Asimakopoulos B. The COVID-19 pandemic triggers changes on the field of cross-border reproductive care. *Clin Res Obstetrics Gynecol* 2020; 3(2): 1-3.
- [5] Lawson AK, McQueen DB, Swanson AC, Confino R, Feinberg EC, Pavone ME. Psychological distress and postponed fertility care during the COVID-19 pandemic. *J Assist Reprod Genet.* 2021; 38(2): 333-41. doi: 10.1007/s10815-020-02023-x
- [6] Boivin J, Harrison C, Mathur R, Burns G, Pericleous-Smith A, Gameiro S. Patient experiences of fertility clinic closure during the COVID-19 pandemic: appraisals, coping and emotions. *Hum Reprod.* 2020; 35(11): 2556-66. doi: 10.1093/humrep/deaa218
- [7] Everingham S, Whittaker A. The impact of Covid-19 on gamete shipping by Australian and New Zealand patients. *Aust N Z J Obstet Gynaecol.* 2022. doi: 10.1111/ajo.13623
- [8] Luppi F, Arpino B, Rosina A. The impact of COVID-19 on fertility plans in Italy, Germany, France, Spain, and the United Kingdom. *Demographic Research.* 2020; 43(47): 1399-412.
- [9] Sun CT. Current status and analysis of reproductive tourism in the context of globalization. *Taiwan J Public Health.* 2017; 36(2): 95-106.
- [10] Martin LJ. Reproductive tourism in the age of globalization. *Globalizations.* 2009; 6(2): 249-63. doi: 10.1080/14747730802500398
- [11] Sun CT. Reconsider contemporary capitalism through reproductive tourism. *Vestnik of Saint Petersburg University. (Sociology).* 2019; 12(1): 36-50. doi: 10.21638/spbu12.2019.103
- [12] American Society of Reproductive Medicine [ASRM]. Patient management and clinical recommendations during the Coronavirus (COVID-19) pandemic. [updated 2020 Mar 17; cited 2020 May 20]. Available from: <https://www.asrm.org/news-and-publications/covid-19/statements/patient-management-and-clinical-recommendations-during-the-coronavirus-covid-19-pandemic/>

# Evaluation Research of the Measure to Monitor the Outbreak in Buntharik District, Ubon Ratchathani Province, Thailand to Control the Situation and Prevent the Spread of the Coronavirus Disease 2019

Tanong Kamsri <sup>a</sup>, Kopkan Choopan <sup>b, \*</sup>

<sup>a</sup> Phibun Mangsahan Hospital, Ubon Ratchathani, Thailand

<sup>b</sup> Buntharik Hospital, Ubon Ratchathani, Thailand

## Abstract

**Background:** This study aimed to evaluate the perceptions of Buntharik District's area-specific COVID-19 control measures and supporting resources, the implementation of each area, and the results of performance.

**Method:** CIPP model was applied to be the framework of study. Qualitative and quantitative methods were used. Multi-stage cluster random sampling was used to sample the study setting in Huai Kha, Kho Lan, and Nong Sano subdistricts. The key informants, including health personnel and members of the local administration organization, health volunteers, and people receiving health services from the COVID-19 control team, collected data.

**Results:** The results found that in first three months of measure implementation, the perception of measure by health personnel was limited only to the group of lead team. At six months, because the Public Health Emergency Operation Center mechanism is used as a coordinating point, the team of operators at all levels is now aware of the procedures. Local government organizations also joined the network to play a significant role in fostering environmental stewardship. Upgrade the facilities, including the COVID-19 quarantine center, to improve and strengthen the operation. The overall mean score of satisfaction of the subjects receiving health care services from the COVID-19 control team was very satisfied ( $4.3\pm 0.6$ ), although the work team's level was moderate ( $3.5\pm 0.5$ ).

**Conclusion:** This study demonstrated that resulted in the communities and individuals in the region responsible for the Buntharik District becoming completely dependent. The different performances of Buntharik District's area-specific COVID-19 control measures are related to the context, the leader's concern, the capacity of team, budget, materials, the attitude of the team, and social capital. Therefore, support for the necessary resources at all levels is still needed. Moreover, the key to success should be applied for sustainability of performance, including integration into routine work, the value of helping people, unity of the team, and effective utilization of limited resources.

**Keywords:** Coronavirus 2019, Measures evaluation, Measures implementation

## 1. Introduction

There is a growing COVID-19 outbreak in Thailand, and as a result, many hospitals have made it a priority to provide COVID-19 patients with nursing care by the regulatory requirements that must be met to avoid infection in healthcare

facilities. Numerous patients are regularly present in the outpatient area. Therefore, it's critical to prevent the transmission of COVID-19 to at-risk groups, such as the elderly and people with chronic illnesses. All provincial governors are contacted by the National Communicable Disease

---

\* Corresponding author.

E-mail address: kopkan1979@hotmail.com (Kopkan Choopan)

Committee to offer their support [1].

The Communicable Diseases Act of Thailand (B.E. 2015) declared COVID-19 a dangerous infectious disease on February 26, 2020. By emergency proclamation B.E. 2005, the prime minister declared an emergency on March 25, 2020. Section 9 of Emergency Proclamation B.E. 2005 (No. 1) sets rules and regulations for the relevant government agencies by March 26, 2020, providing for the emergency's prompt resolution and preventing other serious incidents. The Ministry of Public Health has proposed the Public Health Guidelines in accordance with these standards for the implementation of disease prevention measures required by the government to control the COVID-19 outbreak [2].

Additionally, a manual for public health workers was released on how to manage crises like the COVID-19 epidemic in Thailand to lower the risk of transmission, diminish the adverse impacts on human health, the economy, and society, and increase national security [3]. The guidelines for emergency response are summarized in six key measures (6C), which are as follows: law enforcement, including a coordinated and joint information center; screening and surveillance of patients at checkpoints, hospitals, and communities (capture); case management and infection control; contact tracing; communication; and community intervention. By the Communicable Diseases Act B.E. 2015, the Buntharik District uses the Emergency Operations Center (EOC) mechanism as a coordinating point that connects and complies with the COVID-19 Situation Administration and Communicable Disease Committee, UbonRatchathani Province, to follow the requirements and the proclaimed practice to be able to resolve the emergency, terminate it immediately, and prevent further major events [4]. The COVID-19 epidemic in the Buntharik district provides a unique situation for setting emergency response guidelines into action. A wide range of parties, including the general public, individuals, and departments of agencies, must work together to undertake disease control measures. The operational potential and readiness of something could differ. A full evaluation of the

COVID-19 Control Measures' implementation in the areas responsible for Buntharik District, UbonRatchathani Province, was also discovered to have never occurred. What about challenges? What rules should be followed to solve the issue? to gather empirical data to alter policy management strategies.

This includes maintaining and improving the quality system. Evaluation is being applied in all sectors since it is increasingly recognized as a key method for producing what can be assessed. Because of this, neither an individual nor an organization can avoid the assessment [5].

In this study, the Stufflebeam DL CIPP model was used as a model in four categories [6] describing all parts, including

1. Evaluation of the Context: C, provides essential information to determine whether the COVID-19 control measures are being implemented in the responsible Buntharik District, UbonRatchathani Province. Will it address the problems and needs? Are the execution aims of the measures clear, suitable, and feasible in terms of the likelihood of receiving support from multiple sources?

2. Input evaluation: I, the practicality of measures as well as the suitability and adequacy of resources to be used in operations, such as budget, staff, materials, time, and operational plans, help determine which method to implement. How would you describe your action plan? and how to propose resources for putting the measures into action.

3. Process evaluation: P, which takes into account that each area has its operational processes, strengths, and needs for support to carry out its activities efficiently, evaluates how the COVID-19 control measures have been implemented in the responsible Buntharik District, UbonRatchathani Province. The execution of the policy will also be able to show where further improvement is needed.

4. Product evaluation: P, compares the outcome with the objective or goal set in the measure. It will also aid in determining whether the effects and outcomes of measure implementation will be tracked using data from environmental assessments as well as the relevant

preliminary components and procedures.

The researchers are interested in the implementation of the COVID-19 control measures in the region accountable for Buntharik District, province of UbonRatchathani. The study's findings can be applied as a guideline for overcoming challenges and improving the implementation of disease control strategies. It could be the starting point for the future development of illness management strategies already employed elsewhere.

## 2. Methods

The purpose of this study was to evaluate how the Buntharik District's area-specific COVID-19 control measures and supporting resources were perceived, as well as how well each area's implementation and performance outcomes satisfied the study's target population.

The researchers used a mixed research design for both the quantitative and qualitative studies. The gathering of data occurred in September 2021. The UbonRatchathani Provincial Public Health Office's Human Research Ethics Committee submitted the study for its approval (No. SSJ.UB 2021-069 was approved on August 27, 2021).

### 2.1. Randomization and area sampling

Using multi-stage cluster sampling, the subdistricts of Huai Kha, Kho Lan, Na Pho, Nong Sano, Non Kho, Bua Ngam, Ban Maed, and Phon Ngam were chosen. Three subdistricts and three subdistrict health-promoting hospitals were chosen using simple random sampling. Then, using purposive sampling, teams of subdistrict health-promoting hospitals chose two community-level teams for each hospital, as shown in Fig. 1.

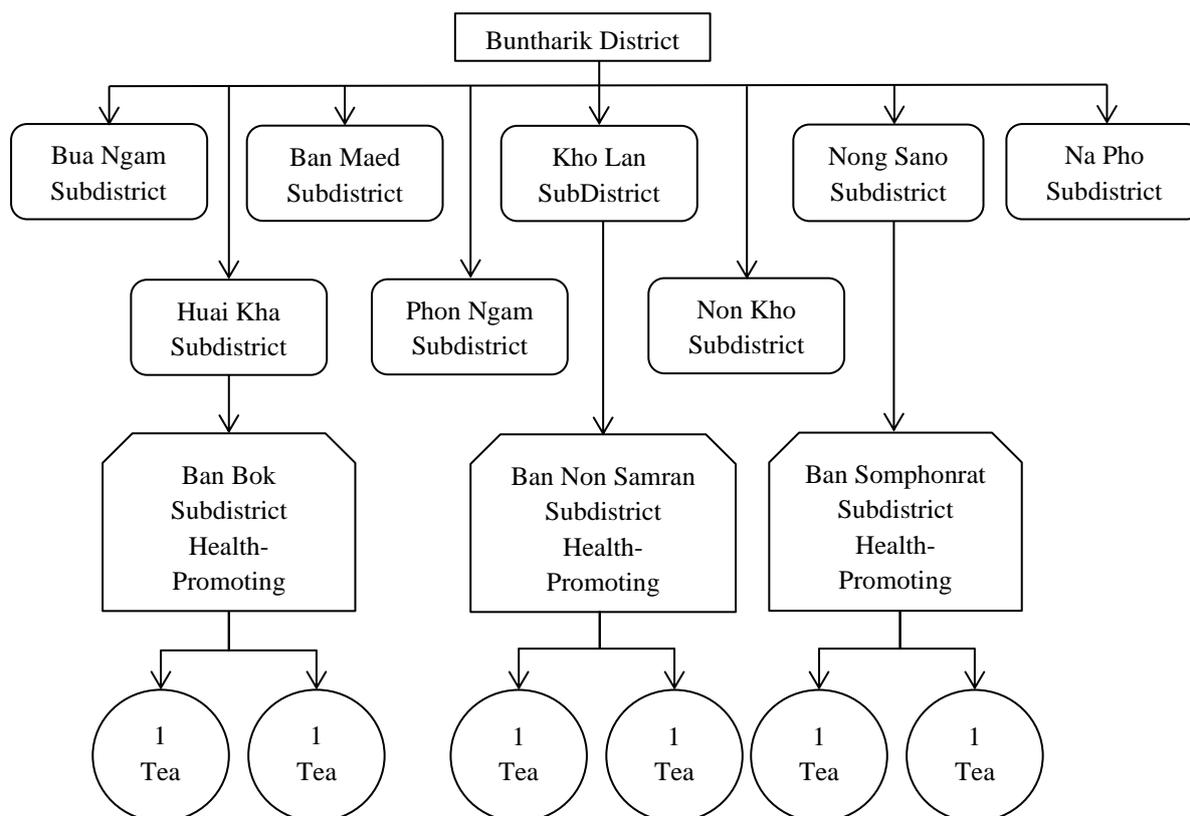


Fig. 1. Randomization and area sampling

## 2.2. Group of quality informants

Among the important informants are those implementing COVID-19 control measures in the accountable Buntharik District, Ubon Ratchathani Province.

### 2.2.1. Selection criteria for informants

Prior to using purposive sampling to identify the informants, the researchers created the following criteria:

1. In the case of personnel working under COVID-19 control measures in the accountable Buntharik District, Ubon Ratchathani Province,
  - A person who can communicate in Thai.
  - It would be willing to offer more information.
2. In the case of the targeted users.
  - They lived in the study area, which is an area administered by three subdistrict health-promoting hospitals: Ban Bok Subdistrict Health-Promoting Hospital in the Huai Kha Subdistrict, Ban Non Samran Subdistrict Health-Promoting Hospital in the Kho Lan Subdistrict, and Ban Somphonrat Subdistrict Health-Promoting Hospital in the Nong Sano Subdistrict.
  - It used to get services from COVID-19 control measures activities in the responsibility region, Buntharik District, Ubon Ratchathani Province.
  - A person who can communicate in Thai.
  - It would be willing to offer more information.

### 2.2.2. Data collection and analysis

1. In-depth interviews revealed that administrators at the district level included the district chief of Buntharik, the hospital's director, the district's director of public health, and the assistant to the district's director of public health.

2. The focus group discussion included representatives from the Ban Bok Subdistrict Health-Promoting Hospital in the Huai Kha SubDistrict, Ban Non Samran Subdistrict Health-Promoting Hospital in the Kho Lan Subdistrict, and Ban Somphonrat Subdistrict Health-

Promoting Hospital in the Nong Sano Subdistrict. They also included the director of the subdistrict health-promoting hospital, the president of the subdistrict administrative organization, and the subdistrict headmen in each subdistrict.

3. A focus group discussion revealed that the team that executes responsibilities as a team implementing COVID-19 control measures at the subdistrict and community levels consists of one nurse at each subdistrict health-promoting hospital, one village headman, one member of the subdistrict administrative organization, and one village health volunteer. The three subdistrict hospitals that encourage health are Ban Somphonrat Subdistrict Health-Promoting Hospital, Ban Non Samran Subdistrict Health-Promoting Hospital, and Ban Bok Subdistrict Health-Promoting Hospital.

4. In-depth interviews revealed that one or two service users from each subdistrict health-promoting hospital, Ban Bok Subdistrict Health-Promoting Hospital, Ban Non Samran Subdistrict Health-Promoting Hospital, and Ban Somphonrat Subdistrict Health-Promoting Hospital, were among those who benefited from COVID-19 control measures in the responsible Buntharik District, Ubon Ratchathani Province.

5. In-depth interviews and focus group discussions covered the main challenges related to resource awareness, implementation, operational patterns that exist in each area, and performance as a result. To clarify, understand, and synthesize knowledge about the research's context, data analysis uses content analytics. The main findings of the evaluation of the implementation of COVID-19 control measures in the relevant Buntharik District region after considering the perspectives into consideration are also described.

## 2.3. Group of quantitative informants

A sample from Ban Somphonrat was taken using a simple random sampling method from three regions under the control of the Ban Bok, Ban Non Samran, and Ban Somphonrat subdistrict health-promoting hospitals. A group of people working on the measure and the target group of people who see outcomes from the use

of the COVID-19 control measure in the responsible region of Ban Somphonrat subdistrict health-promoting hospitals were each given their section of the questionnaire.

### *2.3.1. Sample size determination*

Results from the implementation of COVID-19 control measures will be seen in the Buntharik District in Ubon Ratchathani Province because it is currently unknown how many people live in each area. Krejcie and Morgan's sampling table was used to determine the population size of the service users, who totaled three hundred and thirty-five people, and the sixty-five people who worked on the measures. Therefore, to determine the correct number, utilize a simple random sampling.

### *2.3.2. Research instrument*

Using a questionnaire, the service users who benefit from the implementation of the COVID-19 control measures and the service providers in the Buntharik District, Ubon Ratchathani Province, are evaluated. Most satisfied, highly satisfied, moderately satisfied, less satisfied, and least satisfied are the five levels of satisfaction on the questionnaire. The average score was interpreted using a mean analysis and the following standards: 3.0-3.9 means moderate satisfaction, 4.0-5.0 means very satisfied, and 1.0-2.9 means low satisfaction.

## **3. Result**

### *3.1. District-level implementation of COVID-19 control measures*

The district chief of Buntharik, Mr. Sutin Ngamlert, claimed that preventing outbreaks in the area was his top concern. It all started at the local village subunit. The headman must set up a system to track patients who will regularly return to the Buntharik area, as well as the size and demographics of the community, including the latent population. It is hoped that by building a substantial detention center, the disease will not spread to the Buntharik district. Community members must recognize their responsibility to take care of themselves by implementing DMHTT measures. Group activities should not

be planned, downsized, or delayed; the social sector must collaborate. Public health departments actually must be steady and precise in their execution if they want better outcomes. The extent of the epidemic problem was minimized as a result of the introduction of shared responsibility for village development and practical sustainability.

### *3.2. Recognizing and implementing COVID-19 control measures*

From the perspective of the Buntharik District Public Health, Mr. Uthai Lienghirunthavorn says, "Buntharik district has a sheriff as a commander who is in charge of directing a strong center and delegating duties to everyone to be responsible for their sub-teams". Communication between sub-team leaders and operators takes place across all channels. More than three meetings a week are also held, and everyone is ready to adapt to the situation and follow. Because of this, the group was able to reach swift decisions and form the "four musketeers" network, which included the administrative, public health, community, and village health volunteers. There can be some inconsistencies in internal communication. The Buntharik District's central information system will increase operational precision and accountability.

For the public health assistant, Buntharik recalls that the establishment of an EOC command center was initially required to manage dengue fever when COVID-19 was a threat to public health. To use the monthly meeting to clarify the regulations and the field visits of those involved, the EOC approach was employed in the initial stages of implementing the measure. Even later, the VDO conference was used as a useful means of getting in touch with flexible operators. The operating model is recognized as the first district in the province of Ubon Ratchathani with a technique to detect high-risk visitors more than a week in advance and may successfully prevent COVID-19 infection.

Sheriff Buntharik assigned Dr. Tanong Kamsri, the director of Buntharik Hospital, the responsibility of acting as the deputy commander or supervisor of an EOC operation that comprised participants from all sectors. The main meeting

and a quick-line group meet once per week to discuss and monitor the operations.

#### Outcomes

1. The administration of the Sinovac vaccination policy has changed, along with the implementation of preventative measures for the prevention of COVID-19 by administering only 34% of the COVID-19 vaccine, which may not be as scheduled for the target group of “608” due to older patients' resistance to vaccination and problems with vaccine impairment.

2. The Buntharik district network's operations can be improved by connecting with the district network at the district level, allowing patients to receive care in three hours.

3. Buntharik Hospital can manage its patient load more effectively by providing services. The drug distribution system has been developed to accommodate the new typical circumstance where more than 80% of patients do not require hospitalization. Thus, there is less labor to be done, and patients are pleased to wait for their medication at home. However, people must understand how to deal with hypo- and hyperglycemia, as well as how to treat and monitor disorders such as diabetes.

4. To have enough staff for procedures, Buntharik Hospital employed three nurses and two drivers.

5. Death was discovered in four COVID-19 cases.

#### *3.3. Recognition and implementation of the COVID-19 control measure in the case of the Ban Bok Subdistrict Health-Promoting Hospital, Huai Kha Subdistrict*

The directors of Ban Bok, Ban Nong Mek, and Huai Kha subdistrict health-promoting hospitals concurred to implement the suggestions made by the Buntharik District Public Health Office. The president of Huai Kha Subdistrict Administrative Organization and the subdistrict headman of Huai Kha consulted the appropriate team to design a preliminary operating model.

1. When people from high-risk areas visit the Huai Kha Subdistrict area, find a way to notify the local headman so that detention can continue if it is required.

2. We can gather information to provide first aid to the targeted patients by producing five hundred and thirty-six sets of survival packs that cost seven hundred baht per set.

3. Investigate the location of a waiting area in the Huai Kha Subdistrict. In Huai Lamuad, a waiting area is now being constructed.

#### Outcomes

1. With everyone involved, develop a plan so that everyone is aware of the same specifics. Give this responsibility to the village's main responsible official and encourage the eighty-five local health volunteers to play their parts as effectively as possible to promote the public health of Buntharik District and Buntharik Hospital.

2. All patients received preventative care from all six villages in the care region, and no cases of contaminated patients were found.

3. Plan to get financing from the administrative organization's budget for the purchase of a single pickup truck that will be used for the secure delivery of patients and hazardous waste from the neighborhood to Buntharik Hospital.

#### *3.4. Recognition and Implementation of the COVID-19 Control Measure in the Case of the Ban Non Samran Subdistrict Health-Promoting Hospital, Kho Lan Subdistrict.*

Following the recognition of the COVID-19 control measures from Buntharik District, governed by the municipality of Kho Lan Subdistrict, Ban Non Samran, Ban Nong Ruea, and Ban Khon Paen Subdistrict Health-Promoting Hospital have integrated operations to provide patient care services by the following control measures:

1. Give the in-charge subdistrict team the task of visiting each of the eighteen villages that make up the Kho Lan Subdistrict, which has a population of about thirteen thousand people, to assess the situation and the district's goals. They will be better able to choose a place to keep someone for a specific amount of time, comprehend the importance of surveillance for locals returning from overseas, and communicate their findings to village health volunteers or local officials.

2. Meetings were held to create action plans for measures and improve the skills of village health volunteers in order to establish a good comprehension of each village in the Kho Lan Subdistrict.

3. The village health volunteer team should be required to develop an action plan for each region, which should include contact via group lines, meetings with the village chief, and in-person interactions with the subdistrict hospital that promotes health.

4. The Kho Lan Sub-District received five waiting rooms to accommodate patients.

#### Outcomes

The Kho Lan Subdistrict is implementing measures. Applying the measure's guiding principle entails adapting it to the local conditions of each of the eighteen communities while taking into account available resources. Because each place is unique, the operation is moving gradually in that direction. Take advantage of management's ability to handle the available resources, particularly the working-class volunteers who offer health care in the villages.

#### *3.5. Recognition and Implementation of the COVID-19 Control Measure in the Case of the Ban Somphonrat Subdistrict Health-Promoting Hospital, Nong Sano Sub-district.*

The Ban Somphonrat Subdistrict Health-Promoting Hospital is one of the three public healthcare facilities located in the Nong Sano Subdistrict. At a meeting of the subdistrict health-promoting hospital and the Provincial Administrative Organization, the district EOC acknowledged the COVID-19 control measures, and the president of the Nong Sano Subdistrict Administrative Organization, Sheriff Buntharik, arrived to explain. By routinely addressing community health work and attending meetings with Buntharik Hospital, establish a standard operating procedure to carry out such actions and appoint the person in charge of each village immediately. Each person's job is coordinated and supported using contextual management techniques while also taking into account and making use of the available human resources, such as the village health volunteers, to take care

of them. For connected care, responsibilities are distributed in accordance with each person's neighborhood. Before reporting any information on visitors entering the Nong Sano Subdistrict, at least twenty-four hours must pass.

Positivity in the social cost produces a strong social network. Everyone arrived prepared to assist with the event. Realizing that everyone needs to take care of their health is possible. As a result, there are both formal and informal social groups, including local government agencies, residents of the village, and elderly individuals who volunteer to make cloth masks and give them to the community.

The results showed that practitioners were unaware of centralized measures during the first three months. Only the management and responsibility levels give them any recognition. But during the next six months, the team of operators at all levels will be aware of the protocols since the Public Health Emergency Operation Center mechanism is employed as a coordinating point. Organizations from the local government sector have also joined the network to help promote environmental responsibility. To enhance and improve the operation, the facilities, including the COVID-19 quarantine facility, should be upgraded.

#### *3.6. The areas accountable for Buntharik District's satisfaction with the COVID-19 Control Measure*

One hundred eighty-two sample groups at the Ban Somphonrat Health Promoting Hospital in the Nong Sano Subdistrict, Buntharik District, and Ubon Ratchathani Province were limited because the target population size was three hundred and thirty-five people who received work from the operation, but only 54.3% of the total sample could be employed, according to the quantitative findings from the data analysis of the service users. The analysis of the study found that the majority of the service users (54.4%) were female and that 96.2% of them were familiar with the COVID-19 control measure. The level of satisfaction with the results of the implementation of the measures in the five areas is used to gauge how well the aforementioned control measure is

Table 1. The level of satisfaction of service users, by mean and standard deviation

Satisfaction	Mean	SD.	Interpretation
<b>Quality of care according to the measures</b>	<b>4.1</b>	<b>0.6</b>	<b>very satisfied</b>
Support, advice and guidance from staff.	4.8	0.5	very satisfied
Health can be improved by practicing control measures.	3.9	0.5	moderately
Keep the control measures in place in order to feel better.	4.1	0.3	very satisfied
Distress is lessened with controlled care.	3.7	0.5	moderately
Paying attention to control measures might enhance happiness.	3.8	0.6	moderately
<b>Cost savings from control measures and parity in care</b>	<b>4.6</b>	<b>0.6</b>	<b>very satisfied</b>
Receive equal care as other people.	4.8	0.5	very satisfied
It helps you save money.	4.4	0.3	very satisfied
<b>Ease of care in accordance with control measures</b>	<b>4.4</b>	<b>0.8</b>	<b>very satisfied</b>
You sense more comfort in the presence of control measures.	4.9	0.3	very satisfied
There is no need for you to wait around in the hospital.	3.8	0.7	moderately
<b>Control measures affect willingness to provide care</b>	<b>4.4</b>	<b>0.6</b>	<b>very satisfied</b>
Made to receive kind treatment.	4.8	0.4	very satisfied
Helping to receive care voluntarily.	4.7	0.5	very satisfied
You can easily contact the staff.	4.2	0.6	very satisfied
You feel confident sharing your problem with the staff members.	4.0	0.6	very satisfied
<b>Encouraging the potential of family and self-reliance</b>	<b>4.7</b>	<b>0.6</b>	<b>very satisfied</b>
Control measures provide self-care direction.	4.7	0.7	very satisfied
Control measures support instruction in family caregiving.	4.7	0.5	very satisfied
<b>Overview of satisfaction</b>	<b>4.3</b>	<b>0.6</b>	<b>very satisfied</b>

working. The target population who received the work expressed very satisfaction with the aforementioned measure (mean = 4.3, SD = 0.6), including: 1) encouraging the potential of family and self-reliance (mean = 4.7, SD = 0.6). 2) Cost savings from control measures and parity in care (mean = 4.6, SD = 0.6) 3) ease of care in accordance with control measures (mean = 4.4, SD = 0.8), 4) control measures affect willingness to provide care (mean = 4.4, SD = 0.6), and 5) quality of care according to the measures (mean = 4.1, SD = 0.6) as indicated in Table 1.

The target population size of sixty-five people who worked on the measures showed the satisfaction of the service providers was moderate (mean = 3.5, SD = 0.5) in kind, including acceptance of the control measure and its objectives (mean = 3.8, SD = 0.5), 2) the control measure's

objectives and requirements (mean = 3.7, SD = 0.5), 3) inter-organizational communication under control measures (mean = 3.5, SD = 0.5). 4) Policy/Plan and Control Measure Administration (mean = 3.4, SD = 0.6), and 5) Resources to promote the implementation of control measures (mean = 3.0, SD = 0.8).

#### 4. Discussion

The Buntharik district's personnel's recognition of COVID-19 control measures has improved after six months, but this only serves to show the requirement for further information and training in the procedures. This is in accordance with the subdistrict hospital policy evaluation from the 2009 pilot program, which indicated that the policy's comprehension and communication still needed improvement. The policy is known to

most public health sectors. The groups that perform this function outside of public health are still in the closet, though [7]. Public health professionals may be better knowledgeable about COVID-19 control measures since they must act immediately. Because executives at all levels frequently promoted and reinforced the measures through various channels, local practitioners were able to understand and accept the benefits of the measures. Additionally, the network will recognize and comprehend its degree of acceptance by the health care unit, its participation in COVID-19 control measures, its knowledge potential, ability, and work experience in the field that positively affect network collaboration, as well as the capability and preparedness of the community sector [8].

The work of the COVID-19 control team has enabled new, realistic control of the region. This sets the study's target area apart from its surroundings. Considering its limited resources, the COVID-19 control team must plan. It turned out that the measures were put in place in a variety of places and ways. It shows the region's efforts to put the policies into action while maintaining their fundamental ideas and tailoring them to local conditions. Many places can operate continuously due to the advantages of using such techniques.

Particularly at the subdistrict and village levels, public health volunteers were important to the Buntharik District's COVID-19 control efforts. The community's dedicated and volunteer-spirited public health volunteers are a crucial component of success. There is cooperation among network partners and in the community, according to a study about learning lessons from surveillance operations and preventing and controlling COVID-19 in a community of health volunteers in northeastern Thailand [9]. Buntharik District's COVID-19 pandemic crisis has been controlled by focusing on setting up locations for travelers returning from other areas and utilizing thorough screening to separate people in order to stop the infection's spread there. This correlates with research by Leerapan et al. [10], the Muang Tia Subdistrict

Administrative Organization, Lan District, Pattani Province [11], and the community area along the Rim klong Hua Mak Noi, Bangkapi District, Bangkok [12].

Overall and in each area, operational outcomes that were directly evaluated by service users revealed a range of satisfaction levels from moderately satisfied to very satisfied. At the first observation, it appears that the services provided by the Buntharik District COVID-19 control team can satisfy the expected requirements of the target population. However, the control measure operator team discovered after evaluating the performance that overall satisfaction was only moderate and that the resources supporting in its operation were not well received. However, it is a problem that should be investigated further and followed up on after the satisfaction survey. The sample size for service users was three hundred thirty-five, but only one hundred eighty-two respondents, or 54.3% of the total sample, could be used for the analysis, which represents a limitation of the study.

## 5. Conclusion

Workers from a variety of disciplines are needed in order to carry out the COVID-19 control measures in the Buntharik District, Ubon Ratchathani Province, according to the central operations. However, operating expenses still have an impact on operators. Despite the COVID-19 control measures' performance, there was a lack of information regarding perceptions of the measures and specifics of work activities in the region's first three months. The region depends on the support, encourages, and clear direction given by management at all levels for the implementation of control measures and to ensure continuity.

## Recommendations

1. The findings are used to develop regional control measures that will provide the intended outcomes in the research region.
2. Conclusions from the study can be applied in various fields to implement COVID-19 management measures sustainably.

## Acknowledgements

A special thanks to all of the study subjects for their cooperation, as well as to all of the staff members at Buntharik Hospital for their help and support during the data collection.

## References

- [1] Ministry of Public Health, Department of Disease Control, National Communicable Disease Committee under the Communicable Disease Act B.E. 2015. Ministry of Public Health's letter: requesting cooperation in implementing measures to reduce congestion in hospitals. [cited 2021 August 10]. Available from: <https://ddc.moph.go.th/dcd/pagecontent.php?page=597&dept=dcd> (in Thai)
- [2] Ministry of Public Health. Public health procedures for controlling the COVID-19 epidemic are outlined in the regulations published under Section 9 of the Emergency Proclamation on Public Administration in Emergency Situations, B.E. 2005, No. 1. [cited 2022 November 29]. Available from: [https://ddc.moph.go.th/viralpneumonia/file/g\\_other/g\\_other02.pdf](https://ddc.moph.go.th/viralpneumonia/file/g_other/g_other02.pdf) (in Thai)
- [3] Ministry of Public Health, Department of Disease Control. An emergency response coronavirus disease 2019 outbreak guide for public health workers in Thailand. [cited 2022 November 29]. Available from: [https://ddc.moph.go.th/viralpneumonia/file/g\\_other/g\\_other05.pdf](https://ddc.moph.go.th/viralpneumonia/file/g_other/g_other05.pdf) (in Thai)
- [4] Ministry of Public Health, Department of Disease Control, National Communicable Disease Committee under the Communicable Diseases Act B.E. 2015. Strategies, measures, and practices for the control of coronavirus disease 2019 in provinces. [cited 2021 August 10]. Available from: <https://ddc.moph.go.th/dcd/pagecontent.php?page=597&dept=dcd> (in Thai)
- [5] Kanchanawasi S. Evaluation theory. Bangkok: Chulalongkorn University Printing House; 2002. (in Thai)
- [6] Stufflebeam DL. The CIPP model for evaluation. In: Kellaghan T, Stufflebeam DL, editors. The international handbook of educational evaluation. Dordrecht: Kluwer Academic Publishers; 2003. p.31-61.
- [7] Buntham K, Setsuphana W, Suthiko C, Thima C, Chanchaiyaruk S, Salim S, et al. District health in the pilot phase of the year 2009 (Research report). Bangkok: Printing House Aid for Veterans with Royal Patronage; 2010. (in Thai)
- [8] Sriwanichakorn S, Wechsutthanon K, Leesmith W, Yana T, Nipaporn S, Bukboon P, et al. Potential and readiness of tripartite member concerning the development of the community health system in 12 sub-districts. [cited 2022 November 30]. Available from: <https://kb.hsri.or.th/dspace/handle/11228/3120?show=full> (in Thai)
- [9] Sridawruang C, Worawong C, Sriring P, Klungklang R, Howarn C, Jaisue D, et al. The lesson learned of implementation role for surveillance, prevention and control of coronavirus disease 2019 in communities among village health volunteers in North Eastern, Thailand. [cited 2022 November 30] Available from: <https://kb.hsri.or.th/dspace/handle/11228/5427> (in Thai)
- [10] Leerapan B, Suphanchaimat R, Teekasap P, Puntusavase P, Jaichuen P, Sornsrivichai V, et al. Thailand's COVID-19 Integrated Systems Simulation Modeling [cited 2022 November 30] Available from: <https://kb.hsri.or.th/dspace/handle/11228/5236?locale-attribute=th> (in Thai)
- [11] Ela S, Wani I, Doloh A, KhaoSung W, Maneenin P. Addressing, response, and prevention of the coronavirus 2019 Muang Tia Subdistrict Administrative Organization, Mae Lan district, Pattani province. [cited 2022 November 30]. Available from: [https://www.hu.ac.th/conference/conference2021/Proceeding/doc/02%20HU/070-HU%20\(P.466%20-%20478\).pdf](https://www.hu.ac.th/conference/conference2021/Proceeding/doc/02%20HU/070-HU%20(P.466%20-%20478).pdf) (in Thai)
- [12] Chuthong S. Disaster management for COVID - 19 in the Rim klong Hua Mak Noi community, Bangkapi District. [cited 2022 November 30]. Available from: <http://www3.ru.ac.th/mpa-abstract/index.php/abstractData/viewIndex/279> (in Thai)

# Factors Associated with Food Safety Knowledge among Food Handlers in Surabaya Culinary Centers, Indonesia

Pradevi Milafitri Farista Ananto, Wandee Sirichokchatchawan \*

College of Public Health Sciences, Chulalongkorn University, Bangkok, Thailand

## Abstract

**Background:** This study aimed to examine the level of food safety knowledge and its associated factors among food handlers in Surabaya Culinary Centers, Indonesia. A cross-sectional study was conducted among 483 food handlers, focusing only with the main chef of the food stall, in all 40 culinary centers in Surabaya, Indonesia.

**Method:** A data was collected through face-to-face interview with a structured questionnaire on general and work-related characteristics, and food safety knowledge. Multistage sampling was applied in this study. Frequency and percentage were reported for categorical data, and median and interquartile range were reported for non-normalized data. Chi-square test and binary logistic regression were performed to identify the associated factors of food safety practices with  $p$ -value  $<0.05$ .

**Results:** Food handlers were mostly 43 years old or below (56.3%), female (82.1%), married (55.2%), never smoked (81.3%), and graduated from grade 10 and above (80.9%). Almost all of them had work experience of 1 year (71.6%) and never received any food training (76.1%). In this study, food safety knowledge was found to be moderate food safety knowledge (59.4%), followed by good food safety knowledge (35.8%), and poor food safety knowledge (4.8%). The results revealed that female (AOR 3.42;  $p$ -value  $<0.001$ ), being married (AOR 2.08;  $p$ -value = 0.003), higher education (AOR 4.2;  $p$ -value  $<0.001$ ), being never smoking (AOR 3.67;  $p$ -value  $<0.001$ ), and had 1 year and 2 years of work experience (AOR 6.99;  $p$ -value = 0.009) and (AOR 8.89;  $p$ -value = 0.004), respectively were associated with good safety knowledge among food handlers in Surabaya Culinary Centers.

**Conclusion:** This study emphasizes that all food handlers may require adequate food safety training to enhance their knowledge. It is recommended that future studies should also focus on finding the factors associated with food safety attitude and practice among food handlers In Surabaya, Indonesia.

**Keywords:** Culinary centers, Food handlers, Food safety, Indonesia, Knowledge

## 1. Introduction

Surabaya is the second largest urbanized city in Indonesia with the largest population. Urbanization has an impact on changing the lifestyles and eating behavior of Surabaya people. Surabaya people are eating out more frequently as a result of urbanization (Health Profile, 2020). Demand for fast food in food establishments or culinary centers is directly proportional to increasing foodborne illnesses in Surabaya city such as food poisoning. A culinary center is a

popular place for dining among local citizens in Indonesia. Surabaya city reported 1430 cases of food poisoning with a population of 39,886,288 which is the highest case of food poisoning among cities in East Java [1]. Foodborne illnesses and food hazard contaminants are noticeably high due to the nature of a dense population, inadequate food handling among food handlers, and poor conditions of water, sanitation, and hygiene. Many studies indicated that food safety has become a concern for public health

\* Corresponding author.

E-mail address: wandee.s@chula.ac.th (Wandee Sirichokchatchawan)

issues [2-7]. Food safety is critical for preventing foodborne illness and improving human health [8]. Food handlers play an important role in the potentially spreading of microbiological hazards and contaminating the *food*. Food safety knowledge is associated with food preparation and sanitation practices among food handlers [9]. Many studies have previously examined food safety knowledge in food handlers [3, 7, 8, 10-27]. Adequate safe food-handling knowledge of food handlers is key to the overall safety and quality of food delivered to the consumer for consumption [10, 28, 29]. However, there are limited studies on food safety knowledge among food handlers in Surabaya culinary centers. Therefore, this study aimed (1) to examine general and work-related characteristics, and level of food safety knowledge, and (2) to determine factors associated with good food safety knowledge among food handlers in Surabaya Culinary Centers, Indonesia.

## 2. Methods

### 2.1. Study design and population

A cross-sectional study was conducted in Surabaya, Indonesia from June to October 2022. 483 food handlers, who had responsibility for cooking the food and willing to participate in the study, were recruited from 40 culinary centers in Surabaya. Food handlers who were deaf and mute were excluded from the study. Multi-stage sampling was used to obtain culinary centers and study participants. First, Surabaya culinary centers were purposively selected because Surabaya is the second largest urbanized city in Indonesia, with high food poisoning cases. Second, food handlers were recruited from each food stall by simple random sampling. Data were collected using face-to-face interviews with a structured questionnaire on the general and work-related characteristics, and food safety knowledge.

### 2.2. Study instrument

A questionnaire was developed and structured into two sections. Section one comprised eight questions regarding personal information of the study participants including age, gender,

educational level, smoking status, work experience in the food establishment, and food safety training experience. Section two covered the food handlers' knowledge on knowledge of microorganisms, cross-contamination, personal hygiene, temperature control, and hygiene sanitation.

The questions on general and work-related characteristics, and food safety knowledge were modified from [2, 26, 30, 31]. The food safety knowledge section included statements related to knowledge of microorganisms, cross-contamination, personal hygiene, temperature control, and hygiene sanitation. This section included 16 statements with "Yes/No" responses. The score ranged from 0 to 16 points.

The questionnaire was translated using back translation from English to Bahasa Indonesia and backwards to ensure the quality and accuracy of translation. Validity and reliability were done in 48 food handlers from other culinary centers before data collection. The Cronbach's alpha with a reliability coefficient was at 0.8 [32].

### 2.3. Data analysis

Data analysis was performed using the Statistical Package for Social Sciences version 28.0. Frequency and percentage were used to describe the food handlers' general characteristics, work experience, food safety training experience, and food safety knowledge. Mean and standard deviation were also reported for participants' age and food safety knowledge score. Chi-square test was first performed for assessing the association between the food handlers' general characteristics, work experience, food safety training experience, and food safety knowledge. Food safety knowledge was categorized into three levels "Good knowledge" (>80% correct answer), "Moderate knowledge" (60%-80% correct answer), and "Poor knowledge" (<60% correct answer) following Bloom's cut-off point. Categorical variables such as age, gender, educational level, smoking status, work experience, and food safety training experience were assigned with codes. Binary logistic regression models were performed to identify the associated factors of good food safety knowledge.

Table 1. Level of food safety knowledge among food handlers in Surabaya Culinary Centers (n = 483)

Food Safety Knowledge Level	Frequency	Percentage
Good	173	35.8
Moderate	287	59.4
Poor	23	4.8
Mean $\pm$ SD score	13.38 $\pm$ 2.07	
Min – Max score	9 – 16	

Table 2. Food safety knowledge statements answered correctly (n= 483)

Statements	Frequency	Percentage
<b>Knowledge of microorganism</b>		
Food that is free from microbial sources of poisoning is safe for health	483	100
The causes of unsafe food for consumption are spoilage and pathogenic microbes	231	47.8
Common signs of microbial contamination of food are moldy, slimy, discolored, and smelly	250	51.8
<b>Cross-contamination</b>		
If a hair is found in the food while eating, then the food has been contaminated	250	51.8
Cross-contamination is the transfer of harmful substances or microorganisms to food from food or from a non-food contact surface, such as equipment, utensils, and hands.	321	66.5
Good packaging for wrapping food is paper/cardboard	447	92.5
<b>Personal hygiene</b>		
When sneezing/coughing while processing/serving the food should have to move away from the food	383	79.3
Hand washing should use clean water with soap	434	89.9
Wearing gloves and hair coverings when processing food can prevent contamination of food	299	61.9
<b>Temperature control</b>		
The most important factors to control the growth of bacteria are temperature and time	475	98.3
Improper temperature storage of food can pose a health hazard to consumers.	483	100
Cooked food should be put in a closed container separately according to the type of food	483	100
The correct method for thawing frozen meat or broiler to keep them overnight at room temperature	483	100
<b>Hygiene sanitation</b>		
Washing the utensils should use three tubs (soaking tub, rinsing tub, sanitizer tub/hot water)	483	100
Sufficient number of showers and wash basins must be available in the food establishment according to density of the food handler and customer	475	98.3
Cleaning and sanitizing equipment and food storage shelves is an important thing to do	483	100

Table 3. Chi-square analysis of independent variables and level of food safety knowledge among food handlers in Surabaya culinary centers (n = 483)

Variables	Level of Food Safety Knowledge, n (%)			p-value
	Good	Moderate	Poor	
<b>Age</b>				
43 years and below	101 (20.9)	156 (32.3)	15 (3.1)	0.475
44 years and above	72 (14.9)	131 (27.1)	8 (1.7)	
Mean ± SD		40.3 ± 10		
<b>Gender</b>				
Male	14 (2.9)	68 (14.1)	4 (0.8)	<0.001*
Female	159 (32.9)	219 (45.3)	19 (3.9)	
<b>Marital status</b>				
Single	30 (6.2)	65 (13.5)	14 (2.9)	<0.001*
Married	118 (24.4)	144 (29.8)	5 (1)	
Divorced	25 (5.2)	78 (16.1)	4 (0.8)	
<b>Educational level</b>				
Grade 9 and below	13 (2.7)	56 (11.6)	23 (4.8)	<0.001*
Grade 10 and above	160 (33.1)	231 (47.8)	0 (0)	
<b>Smoking status</b>				
Daily smoker	14 (2.9)	72 (14.9)	4 (0.8)	<0.001*
Never smoke	159 (32.9)	215 (44.5)	19 (3.9)	
<b>Work experience</b>				
1 year	125 (25.9)	204 (42.2)	17 (3.5)	0.018*
2 years	46 (9.5)	59 (12.2)	5 (1)	
3years	2 (0.4)	24 (5)	1 (0.2)	
<b>Food safety training</b>				
No	144 (29.8)	219 (45.3)	5 (1)	<0.001*
Yes, < 1 year	25 (5.2)	64 (13.3)	17 (3.5)	
Yes, 1 – 2 years	4 (0.8)	4 (0.8)	1 (0.2)	

\*p-value <0.05; Significantly associated with food safety knowledge

Food safety knowledge was regrouped into “Good” and “Poor-Moderate” food safety knowledge because the study was focused on finding associated factors of “good food safety knowledge”. Adjusted odd ratio and 95% confidence intervals were reported for associated factors of good food safety knowledge with a significant level of 0.05.

#### 2.4. Ethical approval

This study was approved by the Health Research Ethics Committee, Faculty of Public Health, Sriwijaya University (28/UN9.FKM/TU.KKE/2022).

### 3. Results

#### 3.1. Food safety knowledge among food handlers in Surabaya Culinary Centers (n = 483)

Assessment of food safety knowledge of food handlers in Surabaya Culinary Centers is summarized in Table 1. The mean score for food safety knowledge was 13.38 (SD = 2.07, range 9 - 16). The respondents reported had good knowledge (35.8%), moderate knowledge (59.4%), and poor knowledge (4.8%). The result showed that the food handler in Surabaya Culinary Centers had a good knowledge of temperature control (98.3%) and hygiene sanitation (98.3%). Moderate knowledge of the respondents regarding cross-contamination (46.6%) and personal hygiene (59.4%). Overall, 36.2% of the participants reported poor knowledge on foodborne microorganisms (data not shown).

In the Table 2 the result shows that the food handler in Surabaya Culinary Centers had a good knowledge of temperature control (98.3%) and

Table 4. Factors associated with food safety knowledge among food handlers in Surabaya culinary centers (n = 483)

Variable	Level of Food Safety Knowledge		p-value	AOR (95% CI)
	Poor-Moderate	Good		
<b>Gender</b>				
Male	72 (14.9)	14 (2.9)		Reference
Female	238 (49.3)	159 (32.9)	<0.001	3.42 (1.86 - 6.27)*
<b>Marital status</b>				
Single	79 (16.4)	30 (6.2)		Reference
Married	149 (30.8)	118 (24.4)	0.003	2.08 (1.28 - 3.39)*
Divorced	82 (17)	25 (5.2)	0.475	0.8 (0.43 - 1.48)
<b>Educational level</b>				
Grade 9 and below	79 (16.4)	13 (2.7)		Reference
Grade 10 and above	231 (47.8)	160 (33.1)	<0.001	4.20 (2.26 - 7.81)*
<b>Smoking status</b>				
Daily smoker	76 (15.7)	14 (2.9)		Reference
Never smoke	234 (48.4)	159 (32.9)	<0.001	3.67 (2.0 - 6.72)*
<b>Work experience</b>				
1 year	221 (45.8)	125 (5.2)	0.009	6.99 (1.6 - 30.0)*
2 years	64 (13.3)	46 (9.5)	0.004	8.89 (2.0 - 39.4)*
3 years	25 (5.2)	2 (0.4)		Reference
<b>Food safety training</b>				
No	224 (46.4)	144 (29.8)		Reference
Yes, < 1 year	81 (16.8)	25 (5.2)	0.746	0.8 (0.21 - 3.04)
Yes, 1 - 2 years	5 (1)	4 (0.8)	0.178	0.39 (0.1 - 1.55)

\*p-value <0.05; Age was used to the adjusted variable in the models

hygiene sanitation (98.3%). Moderate knowledge of the study participants regarding cross-contamination (46.6%) and personal hygiene (59.4%). Overall, most of the study participants reported poor knowledge regarding knowledge of microorganisms (36.2%).

### 3.2. Association of independent variables and level of food safety knowledge (n = 483)

In total, 483 food handlers completed the questionnaire survey. The majority of study participants were female (82.1%) and married (55.2%). The median age of food handlers was 42 (IQR = 15) and ranged between 18 and 61 years; 56.3% were aged 43 years old or below. The majority of food handlers graduated from grade 10 and above (80.9%). Only 19.1% graduated from grade 9 and below. Most of the food handlers had never smoked (81.3%). Almost all of them had work experience of 1 year

(71.6%) and never received any food training (76.1%) (Table 3).

The associations between all independent variables and food safety knowledge are presented in Table 3. The result showed that gender, marital status, educational level, smoking status, work experience, and food safety training was statistically significantly associated with food safety knowledge.

### 3.3. Associated factors with food safety knowledge among food handlers in Surabaya Culinary Centers

Logistic regression was used to predict the factors associated with good levels of food safety knowledge among food handlers in Surabaya Culinary Centers. Female food handlers were 3.42 times higher odds of having good food safety knowledge than males (AOR 3.42; 95% CI 1.86-6.27). Married food handlers were 2.08 times

more likely to have good food safety knowledge than single (AOR 2.08; 95% CI 1.28-3.39). Food handlers who graduated with Grade 10 and above were 4.2 times more likely to have good food safety knowledge than those who graduated with grade 9 and below (AOR 4.2; 95% CI 2.26-7.81). Food handlers who reported never smoking were 3.67 times more likely to have good food safety knowledge than those who smoked daily (AOR 3.67; 95% CI 2.0-6.72). Lastly, food handlers who had 1 year and 2 years of work experience were 6.99 and 8.89 higher odds of having good food safety knowledge compared to the food handlers who had 3 years of work experience (AOR 6.99; 95% CI 1.6-30.0) and (AOR 8.89; 95% CI 2.0-39.4), respectively (Table 4).

#### 4. Discussion

This study assessed the factors associated with food safety knowledge among food handlers in Surabaya Culinary Centers and showed that only 36% of the food handlers had good level of food safety knowledge. Additionally, food handlers scored better on temperature control and hygiene-sanitation. However, they were less educated about foodborne microorganisms.

Specifically, food handlers in Surabaya Culinary Centers who being female and married reported a greater chance of having good food safety knowledge (AOR 3.42; 95% CI 1.86-6.27) and (AOR 2.08; 95% CI 1.28-3.39), respectively. Most studies have reported a higher proportion of females involvement in food handling than males [33, 34]. Female food handlers are more understanding and concerned with how to process and serve food properly, and more careful in ordering food ingredients to be processed than male food handlers [35]. This result is interestingly supported by a study conducted in Lebanon households which showed that gender and marital status had a significant association with food safety knowledge among Lebanese food handlers [36]. However, this finding is contrary to a related study by Ahmed et al., which found that gender and marital status showed no significant difference regarding food safety knowledge among food handlers in Lahore district, Pakistan [37, 38].

Furthermore, food handlers who graduated from grade 10 and above had higher odds of having good food safety knowledge (AOR 4.2; 95% CI 2.26-7.81), which similar to a study conducted in South Africa that level of education significant associated with level of knowledge on food safety [39]. Plausibly, through education, food handlers are educated on food safety concerns such as personal hygiene and sanitation, temperature control, and cross contamination. Likewise, literate food handlers' will be able to understand guidelines on food safety from a different sources which can increase food safety of food handlers [40].

Food handlers who reported being never smoked were more likely to have good knowledge on food safety (AOR 3.67; 95% CI 2.0-6.72). Though, this finding is difference from a related study by Hossen et al., which found that there were no significant difference observed with smoking status [41]. Nevertheless, a smoking habit of food handlers may link to a personal hygiene and cause certain food safety concerns. Nicotine and harmful substances may contaminate in the open food at the time of smoking, which present health risks to customers [42].

The odds of having good food safety knowledge were greater in food handlers who had 1 year and 2 years of work experience (AOR 6.99; 95% CI 1.6-30.0) and (AOR 8.89; 95% CI 2.0-39.4), respectively. This finding corroborates with the previous study by [Alemayehu et al., which indicated that there was a significant positive association between work experience and food safety knowledge. Experience may possibly assist food handlers to gain be more knowledgeable on food safety [43].

#### 5. Conclusion

In summary, majority of food handlers in Surabaya Culinary Centers have a moderate level of food safety knowledge. There is a need to improve their food safety knowledge. The results indicated that being female, married, higher educational level, being never smoked, and had 1 year or 2 years work experiences are associated with good food safety knowledge in

food handlers in Surabaya Culinary Centers. The findings also emphasize that all food handlers may require adequate food safety training. It might be because the food safety training programs which may can enhance the knowledge of food microorganisms among food handlers which can enhance their knowledge. Therefore, the food safety training program should focus on clear guidelines addressing food safety.

### Recommendations

Future studies should consider investigating the food safety attitudes and practices, and associated factors among food handlers in Surabaya, Indonesia in order to minimize foodborne illnesses in Surabaya, Indonesia.

### Acknowledgements

The authors would like to thank Professor Dr. Ratana Somrongsong and Associate Professor Nutta Taneepanichskul for providing valuable guidance. We would also like to express the gratitude to all the culinary centers and food handlers who contributed to this study.

### References

- [1] Indonesia. Health profile of Indonesia 2020. Jakarta: Ministry of Health of Republic of Indonesia; 2020.
- [2] Shewasinad Yehualashet S, Asefa KK, Mekonnen AG, Gemeda BN, Shiferaw WS, Aynalem YA, et al. Predictors of adherence to COVID-19 prevention measure among communities in North Shoa Zone, Ethiopia based on health belief model: A cross-sectional study. *PLoS One*. 2021; 16(1): e0246006. doi: 10.1371/journal.pone.0246006
- [3] Natnael T, Adane M, Alemnew Y, Andualem A, Hailu F. COVID-19 knowledge, attitude and frequent hand hygiene practices among taxi drivers and associated factors in urban areas of Ethiopia. *PLoS One*. 2021; 16(8): e0253452. doi: 10.1371/journal.pone.0253452
- [4] Ma NL, Peng W, Soon CF, Noor Hassim MF, Misbah S, Rahmat Z, et al. Covid-19 pandemic in the lens of food safety and security. *Environ Res*. 2021; 193: 110405. doi: 10.1016/j.envres.2020.110405
- [5] Soon JM, Vanany I, Abdul Wahab IR, Hamdan RH, Jamaludin MH. Food safety and evaluation of intention to practice safe eating out measures during COVID-19: Cross sectional study in Indonesia and Malaysia. *Food Control*. 2021; 125: 107920. doi: 10.1016/j.foodcont.2021.107920
- [6] Mucinhato RMD, da Cunha DT, Barros SCF, Zanin LM, Auad LI, Weis GCC, et al. Behavioral predictors of household food-safety practices during the COVID-19 pandemic: Extending the theory of planned behavior. *Food Control*. 2022; 134: 108719. doi: 10.1016/j.foodcont.2021.108719
- [7] Mirzaei A, Nourmoradi H, Zavareh MSA, Jalilian M, Mansourian M, Mazloomi S, et al. Food Safety knowledge and practices of male adolescents in West of Iran. *Open Access Maced J Med Sci*. 2018; 6(5): 908-12. doi: 10.3889/oamjms.2018.175
- [8] Brown PT. Food safety knowledge of undergraduate nutrition majors vs. hospitality management majors. Kent State University College of Education; 2017.
- [9] Widayanti YT. Hubungan Antara Pengetahuan dan Perilaku Terkait Keamanan Pangan pada Wanita yang Bekerja di Universitas Muhammadiyah Surakarta. Surakarta: Universitas Muhammadiyah Surakarta; 2019.
- [10] Adesokan HK, Akinseye VO, Adesokan GA. Food safety training is associated with improved knowledge and behaviours among foodservice establishments' workers. *Int J Food Sci*. 2015; 2015: 328761. doi: 10.1155/2015/328761
- [11] Buccheri C, Mammina C, Giammanco S, Giammanco M, Guardia ML, Casuccio A. Knowledge, attitudes and self-reported practices of food service staff in nursing homes and long-term care facilities. *Food Control*. 2010; 21(10): 1367-73. doi: 10.1016/j.foodcont.2010.04.010
- [12] Budiyo H, Junaedi, Isnawati, T W. Tingkat Pengetahuan dan Praktik Penjamah Makanan Tentang Higiene dan Sanitasi Makanan pada Warung Makan di Kota Surabaya Tahun 2008. *Jurnal Promosi Indonesia*. 2009; 4(1): 50-60.
- [13] Gemeda TE, Asayehu TT, Abdisa M, Fekadu H. Assessment of knowledge, attitude and practices of food handlers in nekemte referral hospital, Wollega, Ethiopia. *J Nutr Health Food Eng*. 2018; 8(1): 00262. doi: 10.15406/jnhfe.2018.08.00262

- [14] Gusdya TJ. Hubungan Pengetahuan, Personal Hygiene dan Motif Ekonomi dengan Keamanan Pangan Jajanan Bakso Bakar di Kota Padang. Sekolah Tinggi Ilmu Kesehatan Perintis Padang; 2020.
- [15] Jones TF, Angulo FJ. Eating in restaurants: a risk factor for foodborne disease? *Clin Infect Dis.* 2006; 43(10): 1324-8. doi: 10.1086/508540
- [16] Parry-Hanson Kunadu A, Ofosu DB, Aboagye E, Tano-Debrah K. Food safety knowledge, attitudes and self-reported practices of food handlers in institutional foodservice in Accra, Ghana. *Food Control.* 2016; 69: 324-30. doi: 10.1016/j.foodcont.2016.05.011
- [17] Launiala A. How much can a KAP survey tell us about people's knowledge, attitudes and practices? Some observations from medical anthropology research on malaria in pregnancy in Malawi. *Anthropology Matter.* 2009; 11(1): 1-13. doi: 10.22582/am.v11i1.31
- [18] Luo L, Ni J, Zhou M, Wang C, Wen W, Jiang J, et al. Food safety knowledge, attitudes, and self-reported practices among medical staff in china before, during and after the COVID-19 pandemic. *Risk Manag Healthc Policy.* 2021; 14: 5027-38. doi: 10.2147/RMHP.S339274
- [19] Meikawati W, Astuti R, Susilowati. Hubungan Pengetahuan dan Sikap Petugas Penjamah Makanan dengan Praktek Higiene Sanitasi Makanan di Unit Gizi RSJD Dr. Amino Gondohutomo Semarang. *Jurnal Kesehatan Masyarakat.* 2010; 6(2).
- [20] Meysenburg R, Albrecht JA, Litchfield R, Ritter-Gooder PK. Food safety knowledge, practices and beliefs of primary food preparers in families with young children. A mixed methods study. *Appetite.* 2014; 73: 121-31. doi: 10.1016/j.appet.2013.10.015
- [21] Mulyani R. Pengetahuan, Sikap, dan Perilaku Higiene Pengolah Makanan. *Jurnal Ilmiah Keperawatan Sai Betik.* 2014; 10(1): 7. doi: 10.26630/jkep.v10i1.309
- [22] Omar SS. Food safety knowledge of street food vendors in downtown Amman-Jordan. *Eurasia J Biosci.* 2020; 14(2): 3601-6.
- [23] Osaili TM, Al-Nabulsi AA, Allah Krasneh HD. Food safety knowledge among foodservice staff at the universities in Jordan. *Food Control.* 2018; 89: 167-76. doi: 10.1016/j.foodcont.2018.02.011
- [24] Septiyani D, Suryani D, Yulianto A. Hubungan Pengetahuan, Sikap, Tingkat Pendidikan dan Usia dengan Perilaku Keamanan Pangan Ibu Rumah Tangga di Kecamatan Pasaleman, Cirebon. *Gorontalo Journal of Public Health.* 2021; 4(1): 45-54.
- [25] Sharif L, Obaidat M, Al-Dalalah M. Food Hygiene Knowledge, Attitudes and Practices of the Food Handlers in the Military Hospitals. *Food Nutr Sci.* 2013; 4(3): 245-51. doi: 10.4236/fns.2013.43033.
- [26] Sirichokchatchawan W, Taneepanichskul N, Prapasarakul N. Predictors of knowledge, attitudes, and practices towards food safety among food handlers in Bangkok, Thailand. *Food Control.* 2021; 126: 108020. doi: 10.1016/j.foodcont.2021.108020
- [27] Wan Nawawi WNF, Ramoo V, Chong MC, Zaini NH, Chui PL, Abdul Mulud Z. The food safety knowledge, attitude and practice of Malaysian food truck vendors during the COVID-19 pandemic. *Healthcare (Basel).* 2022; 10(6). doi: 10.3390/healthcare10060998
- [28] Seaman P, Eves A. The management of food safety—the role of food hygiene training in the UK service sector. *Int J Hosp Manag.* 2006; 25(2): 278-96. doi: 10.1016/j.ijhm.2005.04.004
- [29] Zanin LM, da Cunha DT, de Rosso VV, Capriles VD, Stedefeldt E. Knowledge, attitudes and practices of food handlers in food safety: An integrative review. *Food Res Int.* 2017; 100(Pt 1): 53-62. doi: 10.1016/j.foodres.2017.07.042
- [30] Andualem A, Tegegne B, Ademe S, Natnael T, Berihun G, Abebe M, et al. COVID-19 infection prevention practices among a sample of food handlers of food and drink establishments in Ethiopia. *PLoS One.* 2022; 17(1): e0259851. doi: 10.1371/journal.pone.0259851
- [31] Ceniti C, Tilocca B, Britti D, Santoro A, Costanzo N. Food safety concerns in “COVID-19 Era”. *Microbiol Res.* 2021; 12(1): 53-68.
- [32] Tavakol M, Dennick R. Making sense of Cronbach's alpha. *Int J Med Educ.* 2011; 2: 53-5. doi: 10.5116/ijme.4dfb.8dfd
- [33] Soares LS, Almeida RCC, Cerqueira ES, Carvalho JS, Nunes IL. Knowledge, attitudes and practices in food safety and the presence of coagulase-positive staphylococci on hands of food handlers in the schools of Camaçari, Brazil. *Food Control.* 2012; 27(1): 206-13. doi: 10.1016/j.foodcont.2012.03.016
- [34] Mohd. Firdaus Siau A, Son R, Mohhiddin O, Toh PS, Chai LC. Food court hygiene

- assessment and food safety knowledge, attitudes and practices of food handlers in Putrajaya. *Int Food Res J*. 2015; 2(5): 1843-54.
- [35] Nildawati N, Ibrahim H, Mallapiang F, Afifah MK, Bujawati E. Penerapan Personal Hygiene Pada Penjamah Makanan di Pondok Pesantren Kecamatan Biring Kanaya Kota Makassar. *Jurnal Kesehatan Lingkungan*. 2020; 10(2): 68-75. doi: 10.47718/jkl.v10i2.1164
- [36] Hassan HF, Dimassi H, Karam ZN. Self-reported food safety knowledge and practices of Lebanese food handlers in Lebanese households. *Br Food J*. 2018; 120(3): 518-30. doi: 10.1108/BFJ-04-2017-0239
- [37] Rifat MA, Talukdar IH, Lamichhane N, Atarodi V, Alam SS. Food safety knowledge and practices among food handlers in Bangladesh: A systematic review. *Food Control*. 2022; 142: 109262. doi: 10.1016/j.foodcont.2022.109262
- [38] Ahmed MH, Akbar A, Sadiq MB. Cross sectional study on food safety knowledge, attitudes, and practices of food handlers in Lahore district, Pakistan. *Heliyon*. 2021; 7(11): e08420. doi: 10.1016/j.heliyon.2021.e08420
- [39] Nyamakwera F, Muchenje V, Mushongab B, Kandiwa E, Makepe M, Mutero G. Evaluation of meat safety knowledge, attitudes and practices among slaughter house workers of Amathole District in eastern Cape Province, South Africa. *J Food Saf Hyg*. 2017; 3(1-2): 7-15.
- [40] Mohamad Fauzi FJ, Abdul-Mutalib NA. Knowledge, and practice of home-based food handlers in Hulu Selangor, Malaysia regarding food safety. *Biology and Life Sciences Forum*. 2021; 6(1): 12. doi: 10.3390/Foods2021-10930.
- [41] Hossen T, Ferdaus J, Hasan M, Lina N, Das K, Barman K, et al. Food safety knowledge, attitudes and practices of street food vendors in Jashore region, Bangladesh. *Food Science and Technology*. 2021; 41(1): 226-39. doi: 10.1590/fst.1332
- [42] Barnoya J, Glantz SA. Secondhand smoke: the evidence of danger keeps growing. *Am J Med*. 2004; 116(3): 201-2. doi: 10.1016/j.amjmed.2003.11.005
- [43] Alemayehu T, Aderaw Z, Giza M, Diress G. Food Safety Knowledge, Handling Practices and Associated Factors Among Food Handlers Working in Food Establishments in Debre Markos Town, Northwest Ethiopia, 2020: Institution-Based Cross-Sectional Study. *Risk Manag Healthc Policy*. 2021; 14: 1155-63. doi: 10.2147/RMHP.S295974

# Digital Literacy Skills among Village Health Volunteers in Pathumthani Province

Supika Dangkrajang \*, Nathinee Phongphaitoonsin, Sawanee Tengrungsun,  
Manida Manee-in, Alissa Ratanatawan

Department of Community medicine, Faculty of medicine, Thammasat University, Thailand

## Abstract

**Background:** Village Health Volunteers (VHVs) are considered an important mechanism in driving public health works as community health managers. They are change agents with crucial roles in assisting individuals, families, and communities in taking care of themselves. To enhance VHVs' skills to become VHVs 4.0, one of the essential qualifications is having digital literacy. Therefore, we were interested in studying the current situation and ideas for the development of digital literacy skills of the VHVs in Pathumthani Province.

**Method:** Two phases of mixed-method research on the explanatory design were conducted. Phase I was a quantitative study. A survey questionnaire from a sample of 384 VHVs chosen by a simple random sampling technique was collected. Data were analyzed using descriptive statistics. Phase II was a qualitative study. Six focus group discussions with VHVs from 5 districts were conducted. Data were analyzed using content analysis methods.

**Result:** The results showed that the majority of VHVs in Pathumthani used mobile phones or smartphones. They had some basic digital literacy skills to use, understand, and create digital information. They also expressed their desire to improve their skills in these three areas.

**Conclusion:** Currently, VHVs have basic skills in the usage, understanding, and creation of digital technology via smartphones. However, they still need additional training in all three areas to improve their digital literacy skills.

**Keywords:** Digital literacy, Village Health Volunteers, Skills development

## 1. Introduction

Thailand is now advancing into a “digital society” in which information can be distributed rapidly due to the adoption and integration of digital technology. Therefore, it is crucial to ensure that information, especially health-related information, is dispensed correctly and in a timely manner. In addition, the Thai government has encouraged the Thailand 4.0 policy, focusing on using innovations and digital technology as tools to enhance working process, improve efficiency, reduce costs, and promote healthcare service quality, in order to improve health and quality of life for Thais.

Village Health Volunteers (VHVs) is

considered an important mechanism in driving public health works as community health managers. They are change agents with essential roles in assisting individuals, families, and communities in taking care of themselves. To enhance VHVs' skills to become VHV 4.0 as specified in Thailand 4.0 policy, indispensable qualifications are to have digital literacy, health literacy, and a service mind to lead others to good health. Having digital literacy implies that they are able to apply digital technology to their work to create reliable means for timely and effective communication. Currently, there are a few digital technologies that have been developed to assist in VHVs' work such as Smart VHV Application and

\* Corresponding author.

E-mail address: [suphi2515@gmail.com](mailto:suphi2515@gmail.com) (Supika Dangkrajang; Alissa Ratanatawan)

### Smart VHV.

According to a report from the public health information system by Primary Health Care Division, Ministry of Public Health, among 2,688 selected VHVs in Pathumthani, 618 VHVs (22.99 percent) became VHV 4.0 in 2019. The number increased to 102.92 percent in 2020. However, only 14.71 percent of VHVs (1,424 of 9,676) registered in Pathumthani's Smart VHV application, implying much lower digital technology skills among this group.

Digital literacy has a deeper meaning than just knowing how to use digital technology. Having digital literacy is defined as having the ability and skills to use digital technology in any formal and informal situation including work, learning, leisure, and daily life with thoughtful consideration about the ethical and social impacts of the technology. The three main principles of digital literacy competencies are usage, understanding, and creation [1].

There are few studies on the usage of digital literacy. A study about indicators to evaluate skills and knowledge about digital technology in Thai culture was done by Satawedin [2]. The study showed that the evaluation should base on five domains. 1) Digital technology accessibility and proficiency: having skills and knowledge about how to use and find various devices and their applications. 2) Digital communications and collaboration: having skills and knowledge about how to use devices and their applications to communicate and collaborate with stakeholders. 3) Digital safety and protection: having skills and knowledge about how to legally use devices and applications with a responsibility to society. 4) Digital evaluation: having skills and knowledge about how to flexibly and rationally use devices and applications after a thorough assessment. 5) Digital creativity and innovation: having skills and knowledge about how to use devices and applications for continuous development.

In addition, a report about VHVs' skill development which was studied in Suphan Buri Province found that one of the crucial successes of primary care was to have and use appropriate technology [3]. When they had access to an online

network, they could upload their patient information, local news, and related public health situations in their online database. Then the VHVs network could conveniently access the data and quick response to the situation.

Therefore, it is essential to enhance VHVs' skills to make them become VHV 4.0 by encouraging them to develop the ability to have digital literacy, which they can use digital technology in all three competencies: usage, understanding, and creation. Usage includes the ability to use basic computers or smartphones and an internet connection to assess and search for health information. Understanding means they can critically analyze health information from digital sources, have data management skills, and take responsibility in the digital world. Creation in this study is defined as having the ability to create digital content such as text messages and images with proper ethical considerations. However, literature reviews show that there are neither reports about VHVs' digital technology skills nor guidelines for these skill development in Pathumthani province. Therefore, this study aims to study the current situation and ideas for the development of digital literacy skills among VHVs in Pathumthani province.

## 2. Methods

This study was mixed-method research on the explanatory design divided into two phases.

Phase I was a quantitative study. The population of interest was 9,676 VHVs in Pathumthani province. The sample size required for this study based on the sample size calculation technique was 410. We calculated the proportion of the population by the following formula:  $n = p(1-p)/(e^2/z^2) + (p(1-p)/N)$  and then used a simple random sampling technique to choose sub-districts in each of the 7 districts.

A three-part survey questionnaire was used in this phase. In part I, we asked VHVs about their general characteristics. Part II contained 22 questions about the current situation of digital literacy skills concerning the devices that they used. The questions for the current situation were divided into 3 categories: 9 usage skill questions, 4 understanding skill questions, and 5 creation

Table 1. Baseline characteristics of the VHVs in Phase I (n = 384)

Characteristics	No. (%)
<b>Sex</b>	
Male	67 (17.45)
Female	317 (82.55)
<b>Age (years)</b>	
≤ 30	3 (0.78)
31 – 40	27 (7.03)
41 – 50	82 (21.35)
51 – 60	144 (37.50)
> 60	128 (33.34)
<b>Technology used</b>	
Mobile phone / smartphone	354 (92.18)
Computer	37 (9.64)
Tablet	18 (4.69)
None	5(1.30)

skill questions. We used a 3-level Likert scale to assess the VHVs' current situation with digital literacy. A mean score of 2.34-3.00, 1.67-2.33 and 1.00-1.66 represented the frequency whether VHVs always, sometimes and never perform each task, respectively.

Part III was questioned to assess ideas and needs for the development of digital literacy skills: usage, understanding, and creation. The questionnaire was tested for validity and reliability. Every question had an Item Objective Congruence (IOC) score of more than 0.67, passing the criteria which specificity that each question had to get an IOC score of 0.67-1. The Cronbach's Alpha Coefficient was 0.942. Data were analyzed using descriptive statistics.

Phase II was a qualitative study to explain the situation and ideas for improving their skill. We conducted 6 focus group discussions (8-10 VHVs per group) with VHVs from 5 districts. Data were analyzed using content analysis methods. Three main issues that were discussed included usage, understanding, and creation of digital technology. This study received ethical approval from The Human Research Ethics Committee of Thammasat University (Medicine). The ethical approval number was 042/2564.

### 3. Result

Phase I, 384 VHVs responded to the survey:

317 females (82.6%) and 67 males (17.4%). The largest age group was adults aged 51 – 60 years (37.5%). In terms of usage, almost everyone used mobile phones or smartphones (Table 1). They were likely to use social networks such as Line, Facebook, and Instagram as means to contact and coordinate. In terms of understanding, they had some understanding of how to use digital technology such as connecting to the internet, installing mobile applications, checking the reliability of health information, and saving data. In terms of creation, they sometimes created some basic information using digital technology. Their greatest interest was to improve their digital technology usage skills (Table 2).

Phase II. The average age of the group discussion participants was 53.3 years and 94.4 percent were female. Their current situations were categorized into usage, understanding, and creation. In terms of usage, every VHV used mobile phones or smartphones to communicate with villagers, VHVs, and staff of sub-district health-promoting hospitals through the Line application. Other mobile applications that they were required to use were VHV Online and Smart VHV.

*“Right now, smartphone is an important factor in life. Everything (I) know is from a smartphone. Searching. Line group has the*

Table 2. Current situations of digital literacy skills among VHVs in Pathumthani province (n =384)

Digital Literacy	Mean	SD	Interpretation
<b>Usage</b>			
1. Searching for health information on the internet	2.01	.701	Sometimes
2. Sending documents or messages via e-mail	1.56	.683	Never
3. Using applications such as Smart VHV in VHV's work	1.96	.692	Sometimes
4. Sharing health information/knowledge/news on social network such as Line, Facebook, and Instagram	2.17	.709	Sometimes
5. Communicating with healthcare personnel such as physicians, nurses, and personnel of sub-district health-promoting hospital via social networks such as Line, Facebook, Instagram	2.23	.692	Sometimes
6. Communicating with other VHVs via social networks such as Line, Facebook, Instagram	2.43	.653	Always
7. Consulting with healthcare personnel such as physicians, nurses, and personnel of sub-district health promoting hospital about health problems via social network such as Line, Facebook, Instagram	2.21	.691	Sometimes
8. Using word processing or spreadsheet programs such as Microsoft Word or Microsoft Excel	1.39	.603	Never
<b>Understanding</b>			
1. Making internet connection/Installing programs or applications by yourself	1.78	.735	Sometimes
2. Checking for reliability of health information found in the internet before sharing via social network such as Line, Facebook, Instagram	2.01	.739	Sometimes
3. Saving data in your device by yourself	2.05	.744	Sometimes
4. Sharing information with others via social network such as Line, Facebook, Instagram	2.24	.687	Sometimes
<b>Creation</b>			
1. Creating text messages about health to share via social network such as Line, Facebook, Instagram	1.93	.732	Sometimes
2. Creating images about health to share via social network such as Line, Facebook, Instagram	1.87	.765	Sometimes
3. Creating text messages/images to communicate with healthcare personnel such as physicians, nurses, and personnel of sub-district health promoting hospital	2.02	.733	Sometimes
4. Creating text messages/images to consult with healthcare personnel such as physicians, nurses, and personnel in sub-district health promoting hospital about health problems	1.97	.756	Sometimes
5. Having ethical consideration and privacy when creating text messages or images in the internet and social network	2.14	.803	Sometimes

priority (that I) have to pay attention to. In health promoting hospital's Line group, the staff will always tell us about what we have to pay attention to. Also, additional knowledge that we will tell

other villagers, we get it when health promoting hospital tells us in VHV's Line group to tell villagers"

(Female, 44 years old, Nong Suea District)

*“A day without a mobile phone is like living without the four requisites.*

*(Female, 41 years old, Lat Lum Kaeo district)*

In terms of understanding, VHVs tended to think carefully about the information they received before using or reposting it. They were able to send or delete messages, save images or video clips, and install applications. However, they needed help managing memory and checking the features of their smartphone.

*“About sharing, information, if not confident or not sure that it is correct, don’t share it in the Line group. The director (of the Health-promoting hospital) told us that if we want to share, ask him first whether it is true or not. If you aren’t certain, don’t share.”*

*(Female, 46 years old, Lam Luk Ka District)*

*“Most of the time, (I) will ask someone at the health-promoting hospital who is familiar with this thing for help. Or go to a (smartphone) shop. They have ways to move a photo, increase memory, create album, or something. I do not quite understand how.”*

*(Male, 52 years old, Lam Luk Ka District)*

*“Have to ask for permission from patients first that it is for case example. That (we’ll take) the photo of the wound only. That we are doing the wound dressing and why the wound is looking like this. To let others, know that if left untreated, they would become like this.”*

*(Female, 45 years old, Nong Suea District)*

In terms of creation, they could create basic text messages, images, and video clips with an understanding of proper ethical considerations such as asking for permission before recording, and not disclosing patient information.

*“The staff told us to take a photo of the ID and positive ATK result. After we sent them, they will start the process so that we can take the patient to the hospital.”*

*(Female, 53 years old, Mueang District)*

*“(I...) can create some albums about patients and caregivers.”*

*(Female, 50 years old, Lat Lum Kaeo District)*

*“Take photos and save in VHV group album. And create album name for each activity.”*

*(Female, 50 years old, Lat Lum Kaeo District)*

*“If we use any photo, we’d blur the patient’s face, use flowers to cover the patient’s face to hide the face. So that anyone familiar with or knows the patient remembers who this is. And we wouldn’t put the patient’s name in it.”*

*(Female, 45 years old, Nong Suea District)*

When VHVs were asked about their ideas for the development and improvement of digital technology skills in these three categories, they enthusiastically responded. For usage, they wanted to learn how to use various menu commands, perform preliminary quality checks and use various applications. They also requested support for internet usage fees so they could work more efficiently.

*“Would like it to be training, for VHV from each sub-district. But if want it now, it might be difficult because of COVID. But if possible, (I) would like to be this. Because what we use today is smartphones. It is what we have to use. We don’t have to walk a lot. But we use this for work. In the future, VHVs have to use it in all works. Therefore, before that, we should be trained in how to use it.”*

*(Male, 52 years old, Thanyaburee District)*

*“Sometimes, I can’t find the smartphone function. I know only turn on, turn off, and send messages in Line (application). But I don’t know any further.”*

*(Female, 63 years old, Thanyaburee District)*

*“The government gave us first aid bags. But now the necessity to have the bag is much lesser. Smartphone has more priority. Everyone has to use it. It should be supported, more than any other thing. To lessen VHVs’ expenses. Such as ...*

Table 3. Situation and ideas for the development of digital literacy skills among village health volunteers (VHVs) in Pathumthani province from focus group discussions

Digital Literacy	Situation	Ideas for development
<b>Usage</b>	<ul style="list-style-type: none"> <li>• Use Line application on smartphones</li> <li>• Use mobile applications such as VHV Online and Smart VHV</li> <li>• Use Google and YouTube to assess or search for required information</li> </ul>	<ul style="list-style-type: none"> <li>• How to use menu commands on smartphones</li> <li>• Teach older VHVs who were not familiar with the technology how to use mobile application such as Line</li> <li>• How to check for necessary operating systems and specifications of smartphones</li> <li>• Reimbursement for internet usage fee</li> </ul>
<b>Understanding</b>	<ul style="list-style-type: none"> <li>• Tend to think carefully about the information received.</li> <li>• Can perform basic data management tasks</li> <li>• Ask for permission before photo taking, video recording, and sharing.</li> </ul>	<ul style="list-style-type: none"> <li>• How to manage smartphone memory</li> <li>• Additional skills in image file management</li> <li>• Additional knowledge and understanding of smartphone data security and danger in the digital world</li> </ul>
<b>Creation</b>	<ul style="list-style-type: none"> <li>• Create basic text messages, images, and short video clips</li> <li>• Create albums for each category</li> <li>• Perform minimal image editing</li> </ul>	<ul style="list-style-type: none"> <li>• Addition knowledge about how to edit images and video clips</li> </ul>

*someone have to load money in... This month has to load 300 or 400. Yes, there was no payment before. And yes, the workload was not as heavy as today. We didn't have to use smartphones this much."*

*(Female, 45 years old, Nong Suea District)*

To improve their understanding, they wanted to have more understanding about data management and security in the digital world.

*"Someone still doesn't understand that she has to copy and attach files. Someone can do it, but not understand what it means."*

*(Female, 45 years old, Nong Suea District)*

*"We want to know more. This is new for us. We want someone to teach us. Maybe in a group. To prevent us from danger of using technology. Because we are new to this. Those who are very*

*old don't understand. They sometimes randomly press it. It's actually very important. Nowadays, it is something that we don't know. And I feel like being stupid."*

*(Female, 63 years old, Thanyaburee District)*

For creation, they expressed their interest in learning how to edit images and video clips. The also suggested that personal development on digital literacy skills should include continuous training, beginning with the leader of the VHVs who would later transfer the literacy to their team members.

*"Learning...the important thing is to use it after you've learned it. The method is to ... first, select a leader from each community. Then let him teach his his group. Because we don't need 30 or 40 people here. Let the leader take care of them. If team members can't do it, (the leader)*

*will have to do it himself. If he doesn't teach them, he won't be able to complete the assigned work smoothly."*

*(Male, 52 years old, Thanyaburee District)*

#### **4. Discussion**

##### *4.1. Current situations of digital literacy skills among village health volunteers (Table 3)*

*Usage.* VHVs always used digital technology (mobile phones or smartphones) to communicate with other VHVs. The popular application was Line. Two applications that were used in their works such as surveying for mosquito eggs and sending information about patients in the village were VHV Online and Smart VHV. Moreover, VHVs reported using digital technology to assess or search for health information via Google or YouTube on smartphones. The situations were similar to the results from the study of situation and policy for VHVs' skill improvement in Thailand 4.0 era [4] which found that one of the VHVs' competency development was to promote VHV 4.0 policy. Necessary skills for VHV 4.0 were being comfortable with digital technology, having health literacy, having a service mind, and being willing to be a change agent for health. The development process had changed from attending lectures in seminars to encouraging them to learn from other sources such as the Smart VHV application. This idea was also in accordance with VHVs' role in primary health care which stated that VHVs were to function as public health communicators who linked healthcare personnel with people in the village. They had a responsibility in sharing health information and knowledge with their neighbors and key persons in the family. VHVs was also a member of family physician teams who assisted the team by helping them communicate with patients and the community to fasten the consulting, surveillance, and referral process.

*Understanding.* VHVs did not always understand digital technology such as connecting to the internet or installing programs or applications by themselves; checking for the reliability of health information on the internet before sharing in social networks such as Line, Facebook, or Instagram; saving data in the device

by themselves, and sharing information to others in the social network by themselves. The results from focus group discussions showed that VHVs spent some time thinking about the reliability of the data before sharing. They would not share it if they were not certain about the information. Their reliable sources were healthcare personnel in sub-district health-promoting hospitals. VHVs had basic data management skills including taking photos, recording videos, sharing information, and installing applications. However, they needed help in managing data storage on their smartphones. VHVs recognized their roles and responsibility regarding data privacy. They asked for permission before taking photos or recording videos of their patient and sharing them with others. Because most of the VHVs were between 51-60 years old, there was some limitation in understanding how to use digital technology. They tended to solve this problem by asking for help from someone close to them such as family member and healthcare personnel in a sub-district health-promoting hospital. The reason why they understood their role and responsibility in protecting patient privacy was that they were a part of healthcare teams who worked closely with healthcare professionals such as public health practitioners and nurses, and they had learned by seeing good examples from them.

*Creation.* VHVs sometimes created their own content using digital technology such as text messages or images to share health information and communicate with healthcare personnel such as physicians, nurses, and personnel of sub-district health-promoting hospitals via social networks such as Line and Facebook. They thought about ethical issues and privacy when creating text messages and images before sharing them on the internet and social media. The results from focus group discussions showed that VHVs could create and share text messages, take photos, and record videos. They could manage files save them in albums and have minimal skill in photo editing. This might be because VHVs had begun to develop basic digital technology creation skills that were the same basic skills acquired for their daily life. Thinking about other people and did not want to cause them any problems made them

conscious about keeping other people's privacy.

#### *4.2. Ideas for the development of digital literacy skills among village health volunteers in Pathumthani province*

In Table 3, the digital technology skill that VHVs wanted to develop the most was usage, understanding, and creation, respectively. In terms of usage, VHVs' recommendations were mainly about smartphone usage, especially how to use menu commands, and learning about smartphone specifications and operating systems. These ideas show that since smartphone technology had been advancing rapidly if VHVs have fundamental knowledge about smartphone operations, they should be able to use smartphones more efficiently. The result showing that the older group of VHVs were not comfortable with using Line was in accordance with the policy that focused on digital information literacy indicators to promote democratic citizens in the Thai elderly [5]. The policy stated that competency I was about safety in assessing and using digital information. The principal indicators were that the elderly knew and could use digital information safely, had access to varieties of digital information sources, and understand the purpose of the information industry. Competency II was about analyzing and criticizing media. The elderly should be able to evaluate the reliability of the information they received and realize the impact of sharing information sharing, emotional management, and time management. Competency III was about content creation. The elderly should use the information available creatively to be an additional asset to their existing experience and knowledge. Competency IV was about the application. The indicator of this competency was that the elderly should take part in communication for the change process.

Moreover, VHVs recommended that having support to pay for internet usage fees is an important method to help develop their digital technology skills. This was the same recommendation as shown in the study of situation and policy for VHVs' skill improvement in Thailand 4.0 era [4] that recommended

encouraging participation from various sectors in both private and public agencies to support VHVs' fieldwork. One example was to get internet access support for VHVs who lived in rural areas without governmental internet program coverage.

In terms of understanding, VHVs suggested that they wanted to develop smartphone data management and image editing skills such as copying, saving, sending attachments, and forwarding data. They also wanted to understand and be able to deal with data security issues. These demands were similar to five domains in digital awareness skill measurement [2]: digital technology accessibility and proficiency, digital communications and collaboration, digital safety and protection, digital evaluation, and digital creativity and innovation.

In terms of creation, VHVs suggested they increased skills in media editing, both images, and video clip files because the information was usually shared in these formats at present. They had to add extra information to the existing images and compress video files for their convenience in sending them to others. Previous research results [6] showed that village health volunteers should be equipped with competencies, particularly in 3 areas: digital literacy, health literacy, and transformational leadership skills.

## **5. Conclusion**

Currently, VHVs have basic skills in using, understanding, and creating digital literacy via smartphones. However, they still need additional training in all three areas to improve their digital literacy skills. In usage, VHVs' recommendations were mainly about smartphone usage, especially how to use menu commands, and learning about smartphone specifications and operating systems. In understanding, they wanted to develop smartphone data management and image editing skills such as copying, saving, sending attachments, and forwarding data. They also wanted to understand and be able to deal with data security issues. In creation, they increased their skills in media editing, both images, and video clip files.

### Recommendation

According to the results, the digital literacy skills course for VHV may include application and device storage management, photo editing, digital collaboration tools, personal digital security, and online safety.

### Acknowledgment

This study was funded by the Faculty of Medicine, Thammasat University in 2021. We would like to show our gratitude to Pathumthani Provincial Public Health Office, every district public health office in Pathumthani, Bang Dua Sub-district Health Promoting Hospital, Bueng Kham Phroi Moo 11 and Moo 13 Sub-district Health Promoting Hospital, Khu Bang Luang Sub-district Health Promoting Hospital, Nopparat Sub-district Health Promoting Hospital, and Lam Phak Kut Sub-district Health Promoting Hospital for assistance with contacting VHVs in Pathumthani province for our data collection.

### References

- [1] Digital Literacy Fundamental. [cited 2020 Oct 18]. Available from: <http://mediasmarts.ca/digital-media-literacy-fundamentals/digital-literacy-fundamentals>.
- [2] Satawed P. The development of key indicators for measuring digital literacy skills and competencies in thai-context culture. *Santapol College Academic Journal*. 2019; 5: 274-86.
- [3] Nuchanart N, Petcharak S, Chaovalit S. A Competencies Development of the Village Health Volunteers of Suphan Buri Province. *Journal of MCU Peace Studies*. 2018; 6(2): 768-79.
- [4] Borisut N. The study of situation and village health volunteer development in Thailand 4.0 era. [cited 2020 Oct 15]. Available from: <http://phc.moph.go.th/>
- [5] Thisaphak P, Oranop Na Ayutthaya C, Pathumcharoenwattana W. Media, information, and digital literacy indicators for advocating democratic citizenship of Thai elderly. *Journal of Mass Communication*. 2019; 7(1): 147-90.
- [6] Chanarnupap S, Jitjum P. Roles of village health volunteers in the COVID-19 pandemic crisis. *Parichart Journal Thaksin University*. 2022; 35(2): 148-64.

# Metformin Activity on Longevity and Mitochondrial Unfolded Protein Response (UPR<sup>mt</sup>) across UPR<sup>mt</sup> Invoked *C. elegans*

Anubhav Aryal, Chutipong Chiamkunakorn, Wichit Suthammarak \*

Department of Biochemistry, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok 10700, Thailand

## Abstract

**Background:** Metformin, a first line drug for the treatment of type 2 diabetes mellitus, has been implicated to slow down ageing in various organisms including *C. elegans*. It has been shown that the drug tends to accumulate in mitochondria. Recently, the mitochondrial unfolded response (UPR<sup>mt</sup>) was shown to affect lifespan in UPR<sup>mt</sup>-activated worms. UPR<sup>mt</sup> is mitochondrial stress response pathway instigated in response to alleviate mitochondrial proteostasis. We, therefore, surmised that metformin might affect ageing by exerting its effect on UPR<sup>mt</sup>. The objective of this study is investigating the interaction of metformin with UPR<sup>mt</sup> on lifespan of worms.

**Methods:** Synchronized 100 to 150 wildtype (N2) worms were laid for both metformin treated and untreated (control) group. The survival of the worms was scored everyday starting from adult day 1 by gentle touch. The UPR<sup>mt</sup> was induced by feeding the nematodes with dsRNA-producing (RNAi) bacteria including *ech-6*, *pdhb-1*, and *wah-1* along with empty vector (EV) as a control. IPTG (isopropyl-β-D-thiogalactoside) at 5 mM was used to activate dsRNA synthesis. Metformin at final concentration of 50 mM was supplemented onto the cultured agar. hsp-6p::GFP was used to observe UPR<sup>mt</sup> starting from day 2 of adult life.

**Results:** Metformin significantly increased lifespan in wildtype worms fed with OP50 bacteria and EV. Lifespan of *ech-6* and *pdhb-1* RNAi worms were found to be significantly reduced in comparison to EV. In contrast, *wah-1* RNAi worms had significantly extended lifespan. Moreover, RNAi knockdown of *atfs-1* which leads to inactivation of UPR<sup>mt</sup>, did not change the lifespan of N2 worms with respect to EV. Upon blocking UPR<sup>mt</sup> by *atfs-1* RNAi, the lifespan reduction conferred by *pdhb-1* RNAi was significantly rescued towards normal lifespan. Metformin, however, significantly decreased the lifespan of all RNAis except *pdhb-1*, where it had no significant change in lifespan. Metformin also significantly suppressed the UPR<sup>mt</sup> at different adulthood days in *ech-6* and *wah-1* RNAi.

**Conclusion:** Metformin extended the lifespan in *C. elegans*. The variable nature of lifespan in UPR<sup>mt</sup> invoked worms (*ech-6*, *wah-1* and *pdhb-1*) delineates the complex nature of UPR<sup>mt</sup> in relation with the lifespan. Metformin suppressed UPR<sup>mt</sup> in *ech-6* and *wah-1* despite decreasing their lifespan. This lifespan reducing effect reiterated with *atfs-1* and therefore hints that wildtype expression levels of *ech-6*, *wah-1* and *atfs-1* is required for metformin induced lifespan extension. Also, the amelioration of mitochondrial stress by the drug at specific time points during life might not be sufficient to confer longevity. The lifespan phenotype conferred by UPR<sup>mt</sup> in *pdhb-1* was abolished when fed together with *atfs-1* RNAi. This indicates the clear role of UPR<sup>mt</sup> in lifespan regulation. Interestingly, metformin did not change the lifespan of *pdhb-1*, which suggests that the drug might exert its effect by downregulating the function of *pdhb-1*.

**Keywords:** Metformin, *C. elegans*, Ageing, Unfolded Protein Response

## 1. Introduction

Ageing is an inevitable process characterized by physiological and cognitive decline. It is also

an undeniable factor that takes part in abatement of various diseases like diabetes, Alzheimer disease, cardiovascular diseases, cancers, obesity, and

\* Corresponding author.

E-mail address: wichit.sut@mahidol.edu (Wichit Suthammarak)

other metabolic abnormalities [1]. The increase in life expectancy and hence increase in elderly population has further posed the risk in management of age inflicted disorders and has resulted in urgent need of reliable preventive regimen and therapeutic interventions. As a result, the quest for antiaging therapeutics that improve lifespan as well as healthspan has been accelerated in recent years. Metformin, a first line drug to treat type 2 diabetes mellitus (T2DM), which already had well documented beneficial outcomes in patients having T2DM engendered its preclinical studies in anti-aging domain. Interestingly, metformin significantly increased the lifespan and healthspan in *C. elegans* [2] (invertebrate) and mice model [3] (vertebrate). In humans, metformin decreases the liver gluconeogenesis and hence decreases the blood glucose level and improves insulin sensitivity. However, the molecular mechanism of metformin action is still uncertain. Various studies have suggested the activation of AMPK (Adenosine Monophosphate Kinase), a central regulator of metabolism, to be the target of metformin. In contrast, some studies have also reported AMPK independent mechanisms to be the way of metformin action [4]. Similarly, in *C. elegans*, several mechanisms involve in metformin action include *aak-2* activation (worm orthologue of AMPK), complex I inhibition and mitohormesis, inhibition of folate metabolism and lysosomal pathway. Till this date, metformin has shown to ameliorate the lifespan and healthspan characteristics of various neurodegenerative disease model of *C. elegans* that includes Alzheimer's [5], Parkinson [6] and Huntington's disease [7].

One of the hallmarks of aging is loss of proteostasis. Proteostasis refers to the meticulous control of protein formation, folding, conformational maintenance and degradation [8]. This is regulated by a molecular network that consists of ribosomes, chaperones, and degradation machinery. However, at stressed conditions prompted by oxidants, high temperature, mutations and pharmacological agents, a specific response is employed to ensure protein quality control known as unfolded protein

response (UPR). UPR is divided on the basis of its site of origin; Endoplasmic reticulum associated UPR (UPR<sup>ER</sup>), cytosolic UPR (cyto UPR) and mitochondrial UPR (UPR<sup>mt</sup>). UPR<sup>mt</sup> is the first line of response against mitochondrial perturbation and is regulated by stress associated transcription factor-1 (ATFS-1)[9]. Under normal conditions, ATFS-1 localizes to mitochondria using its MTS (Mitochondrial Targeting Sequence) and is degraded by matrix protease. During stressed conditions, using its nuclear localization sequence (NLS), ATFS-1 relocalizes to nucleus and activates transcription of mitochondrial chaperones like *hsp-6* and *hsp-60* and proteases like CLPP, LON-P1 to aid in protein folding and degradation. Not only limited to proteostasis, UPR<sup>mt</sup> has ever expanding role that spans developmental regulation, signaling in innate immunity, aging, cardioprotection and metabolism. Initially reported human cell lines, the pathways of UPR<sup>mt</sup> have been thoroughly explored using *C. elegans* afterwards. This is solely because of its attributes like: short life cycle (3 days), lifespan of 2 to 3 weeks, relative ease in maintaining and performing genetic experiment via RNAi feeding and the conservation of signaling pathways that operate in higher eukaryotes.

Mitochondrial UPR or UPR<sup>mt</sup> has a complex relationship in relation to aging. Activation of UPR<sup>mt</sup> may decrease or increase the lifespan [10]. The RNAi (RNA interference) knockdown or classic mutant strains pertaining to components of electron transport chain like *nuo-1*, *nuo-6*, *clk-1* and *cco-1* activate UPR<sup>mt</sup> and it increases the lifespan and stress tolerance. Conversely, loss of UPR<sup>mt</sup> via knockdown of *atfs-1* in such mutant strains confer reduction in lifespan and stress tolerance. Moreover, knockdown of other genes involved in mitochondrial matrix and membranes like *ech-6*, *pdhb-1*, *tom-22*, *timm23* and *dnj-21* confer lifespan reduction but *wah-1*, *letm-1* result in lifespan augmentation. Metformin, as mentioned earlier, has lifespan and healthspan promoting traits in wildtype but this has not been characterized in relation with UPR<sup>mt</sup> activated mutants. In addition, metformin is also thought to accumulate in mitochondria [11]. We, therefore, want to explore the interaction of metformin with

UPR<sup>mt</sup> using the UPR<sup>mt</sup>- activated mutants, including *ech-6*, *wah-1* and *pdhb-1* surmising that metformin might affect the lifespan of these mutants with its concomitant impression in UPR<sup>mt</sup>.

## 2. Methods and Materials

### 2.1. Worms and RNAi strains

Nematode strains N2 Bristol (wildtype) and SJ4100 *zcls13[hsp-6::GFP]* were acquired from the Caenorhabditis Genetics Centre (CGC, University of Minnesota, USA). *Escherichia coli* OP50 was used as a standard diet to maintain the worm strains. *E. coli*-based RNAi strains from Ahringer's Library included Empty vector (L4440, EV), *pdhb-1*(pyruvate dehydrogenase beta -subunit-1), *ech-6*(enoyl coenzyme A hydratase-6), *wah-1*(apoptosis inducing factor-1), *atfs-1*(stress activated transcription factor-1). RNAi clones were kindly provided by Prof. Bart P. Braeckman (Ghent University, Belgium) and were verified through end sequencing before application.

### 2.2. Lifespan assay

Wildtype worm strain (N2) was used for survival experiments. Worms were cultured and maintained on NGM plates seeded with OP50. For synchronization, 20-30 young adult worms were allowed to lay eggs on solid media topped with OP50 lawn or RNAi for 3-4 hours. After that, parent worms were removed, and those worm-evacuated egg laden plates were incubated at 20 °C. Upon reaching adult day 1, a total of 100 to 150 worms were assigned to both experimental (drug treated) as well as control group into 4 to 6 plates; each containing 25 worms. Worms were transferred to new plates every day under the same feeding conditions throughout the lifespan. Worms were designated as alive, dead, and censored. Individuals failing to mount response against touch provocation around head and tail regions were deemed dead. Similarly, worms those crawled off the plates, displayed bagging phenotypes or died by vulval outburst were censored.

For feeding based RNAi experiments, RNAi clones were cultured overnight in LB broth

containing 100 ug/ml of ampicillin. RNAi cultures were then aliquoted to 50 ml falcon tube and centrifuged at 4,000 rpm for 5 mins at 4 °C. After that, 45 ml of supernatant was discarded, and the remaining 5 ml was mixed with the pellet and seeded into NGM plates containing 5 mM IPTG to induce dsRNA synthesis. The plates were then left to dry for 24 hours in room temperature. Double RNAi-knockdown experiments were conducted by mixing RNAi bacteria in 1:1 ratio by volume. Metformin and IPTG were mixed in the molten NGM agar at 50 mM and 5 mM final concentration respectively and segregated into individual plates. The drug-based lifespan assay was carried as above using RNAi or OP50 bacteria from egg stage. L4440 (EV) was used as RNAi control.

### 2.3. Fluorescence microscopy

Mixed stages transgenic worms (SJ4100, *hsp-6::gfp*) were fed with control or RNAi clones under drug treated and non-treated conditions for 3-4 hours to yield synchronized worm population. These synchronized worms were transferred to identical plates everyday. Green Fluorescence Protein (GFP) images were captured on different days starting from adult day 2 to examine the expression of HSP-6::GFP. Briefly, 5 worms were employed per condition and transversely arranged in agar pads (2% w/v) and paralysed using 4 microliters of 30 mM sodium azide. An inverted fluorescent microscope equipped with a camera (Ti-S Intensilight Ri1 NIS-D) (Nikon, Tokyo, Japan) & NIS-D Elements software (Nikon, Tokyo, Japan) was used to capture and obtain images for the experiment. Fluorescence image was captured using same intensity across every condition in the given time frame. Image J (Fiji) software was used to calculate the integrated pixel density of the acquired images through free hand ROI tool and normalized by the number of worms per condition. The experiment was conducted in triplicate for every condition.

### 2.4. Statistical Analysis

Log-rank test was used to analyze lifespan results using OASIS [12]. Graph Pad Prism 9.0.2 was used to perform t -test (unpaired) in Results

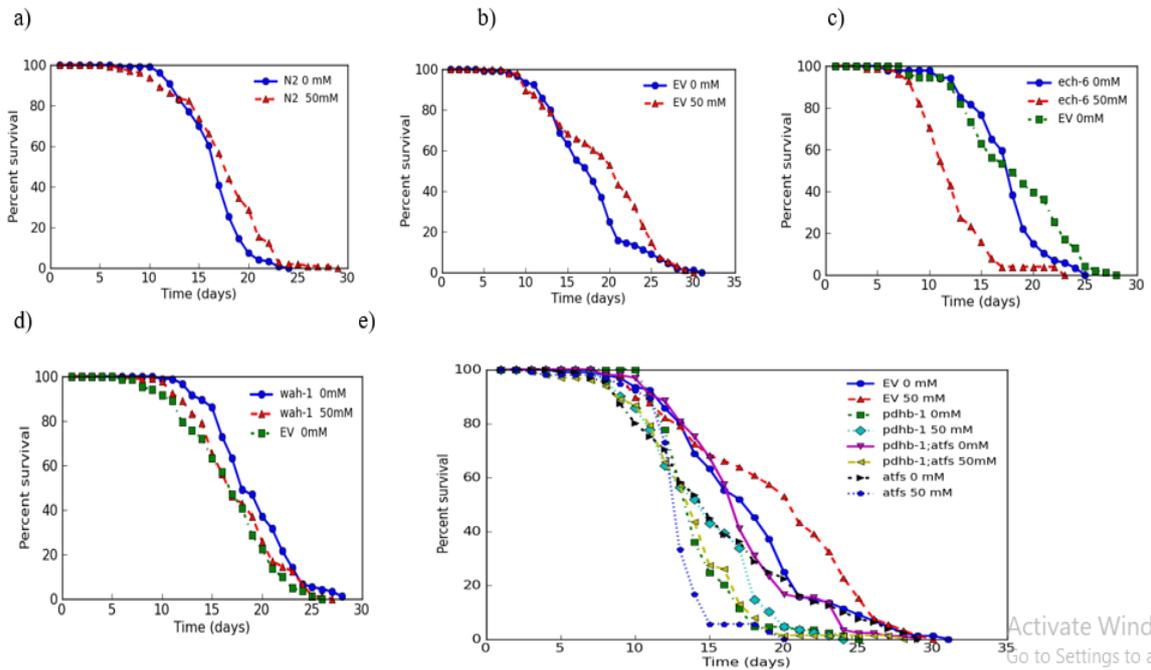


Fig. 1. Lifespan curves of N2 fed with OP50, EV and different RNAi at control (0 mM) and experimental concentration (50 mM) of metformin.

from unfolded protein response. Significant level was determined by  $p < 0.05$ .

### 3. Results

#### 3.1. Metformin delays aging in *C. elegans*

Metformin significantly extended the mean lifespan of wildtype (N2) worms fed with OP50 at 50 mM metformin (Fig. 1a, Table 1), the most efficacious concentration reported by several research articles. Here, the drug also extended median lifespan by 1 day. Similarly, the maximal lifespan of worms upon drug supplementation was 29 days, while the control group was restricted within 24 days. We also asked whether metformin could extend lifespan similarly in the case of control group for RNAi fed worms, also known as EV (Empty Vector) : an *E. coli* HT115 strain transformed with pL4440. As expected, metformin significantly extended EV lifespan by 9.94 % (Fig. 1b, Table 1). Under the same dosage, metformin treatment resulted in 3 extra days of median lifespan in comparison with the control group. Hence, metformin delayed aging in worms fed with OP50 and EV.

#### 3.2. Metformin accelerates aging in *UPR<sup>mt</sup>* activated RNAi except *pdhb-1* with distinct impression on *UPR<sup>mt</sup>*

Using the same dosage as mentioned before, we assessed the metformin effect on lifespan and fluorescence profile of *UPR<sup>mt</sup>* activated mutants. One of such mutants is *ech-6* (Enoyl COA hydratase-6), which functions in branched chain amino acid (BCAA) pathway. *ech-6*(RNAi) has significantly reduced lifespan by when compared with EV (Fig. 1c, Table 1). Metformin treatment significantly decreased the lifespan of *ech-6* by 29.40% (Fig. 1c, Table 1). On the other hand, metformin non-linearly suppressed the *UPR<sup>mt</sup>* (HSP-6::GFP) at different days of adulthood (Fig. 2). Metformin treatment in *ech-6* decreased the lifespan as well as suppressed the *UPR<sup>mt</sup>*.

Using another strain *wah-1* (Apoptosis Inducing factor, AIF homolog) which has significantly augmented lifespan (Fig. 1d, Table 1), we found that metformin treatment, once again, decreased the lifespan by 8.11% percent along with significant suppression of *UPR<sup>mt</sup>*, but only on adult day 8 (Fig. 3). To make the findings

Table 1. Table showing the lifespan data, calculated by log-rank test, for all conditions presented in the Fig. 1. “-” represents the decrease in the given percentage. “wrt” refers to with respect to or in comparison with.

Strain	Conditions		Number of worms	Mean lifespan (days)	Median lifespan (days)	Mean lifespan Percent change of metformin treated group	Maximal Lifespan (days)	p-value
	Metformin concentration							
N2	0 mM		150	16.71	17	+5.80%	24	0.008
	50 mM		150	17.68	18		29	
EV	0 mM		100	17.69	18	+9.94 %	31	0.0238
	50 mM		100	19.45	21		30	
<i>ech-6</i>	0 mM		100	17.48	18	-29.40 %	25	0.0e+00 ( <i>ech-6</i> 0 mM vs <i>ech-6</i> 50 mM)
	50 mM		100	12.34	14		23	
EV control of <i>ech-6</i>	0 mM		100	18.30	18		28	
<i>wah-1</i>	0 mM		100	19.22	18	-8.83 %	29	0.035 ( <i>wah-1</i> 0 mM vs <i>wah-1</i> 50 mM)
	50 mM		100	17.66	17		27	
EV control of <i>wah-1</i>	0 mM		100	16.88	17		26	
<i>pdhb-1</i>	0 mM		100	14.40	14	+2.31%	25	0.14 ( <i>pdhb-1</i> 0mM vs <i>pdhb-1</i> 50mM)
	50 mM		100	14.74	15		24	
<i>pdhb-1</i> ; <i>atfs-1</i>	0 mM		100	17.18	17	-19.20 %	29	4.4e-09 ( <i>pdhb-1</i> 0 mM vs EV 0 mM)
	50 mM		100	13.88	14		28	
<i>atfs-1</i>	0 mM		100	15.83	15	-17.18 %	29	2.0e-07 ( <i>pdhb-1</i> ; <i>atfs</i> 0 mM vs <i>pdhb-1</i> ; <i>atfs-1</i> 50 mM)
	50 mM		100	13.11	13		20	
								0.09 ( <i>atfs-1</i> 0mM vs EV 0mM)

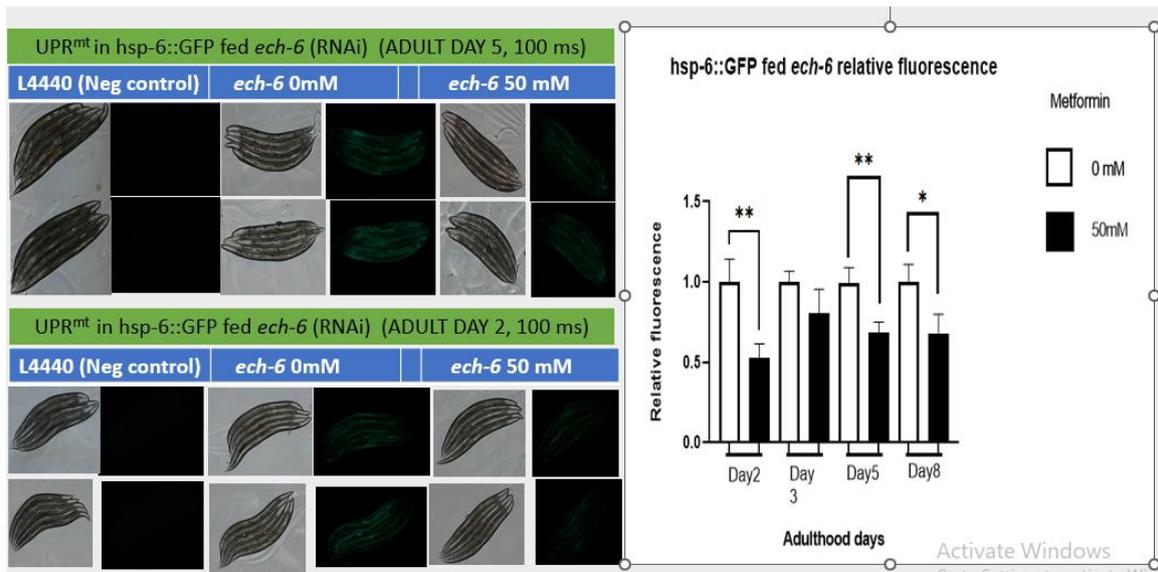


Fig. 2. Diagram on the left shows the representative images, taken under fixed camera settings using reporter strain *hsp-6::gfp*, with and without metformin treatment in *ech-6* at adult day 2 (lower) and adult day 5 (upper). Figure on the right depicts the statistical analysis of diagram (students' t test). "\*" denotes statistical significance where *P*-value <0.05 and "\*\*\*" indicates *P*-value <0.01.

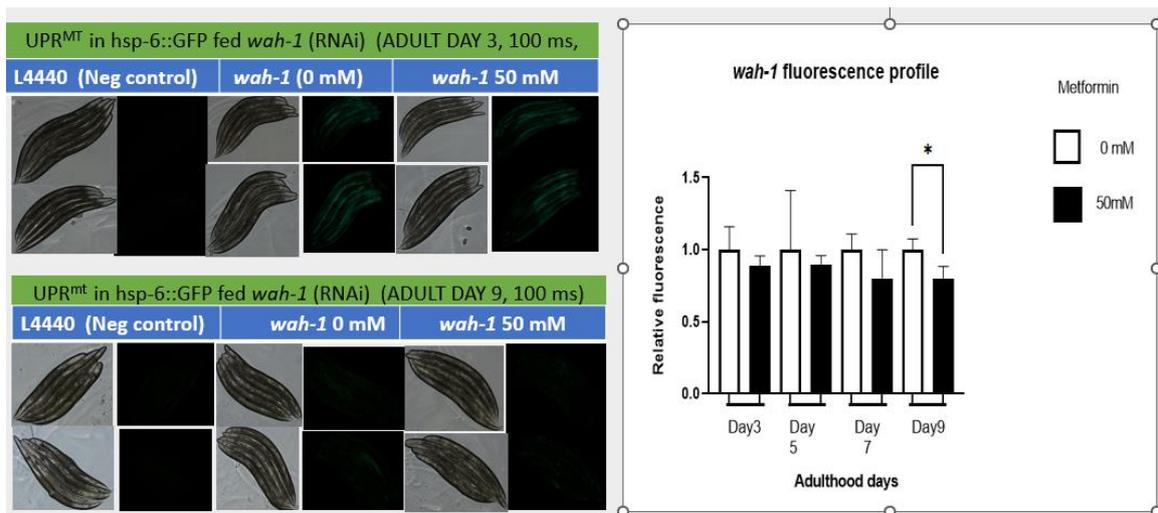


Fig. 3. Diagram on the left shows the representative images, taken under fixed camera settings using reporter strain *hsp-6::gfp*, under metformin treatment in *wah-1* at AD9 (lower) and AD3(upper). Figure on the right depicts the statistical analysis of the diagram (students' t test). "\*" denotes statistical significance where *P*-value <0.05 and "\*\*\*" indicates *P*-value <0.01.

more comprehensive, we again tested *pdhb-1* (RNAi) with metformin. *pdhb-1*, a worm counterpart of human pyruvate dehydrogenase subunit-1, has reduced lifespan (Fig. 1e). Upon metformin treatment, lifespan did not change (Table 1). We could not score the GFP images of UPR<sup>mt</sup> of *pdhb-1* upon metformin

supplementation due to low intensity when compared against RNAi control.

### 3.3. Loss of UPR<sup>mt</sup> reverts lifespan but doesn't ameliorate metformin toxicity

UPR<sup>mt</sup> is regulated by ATFS-1, a transcription factor, which is mainly responsible for the

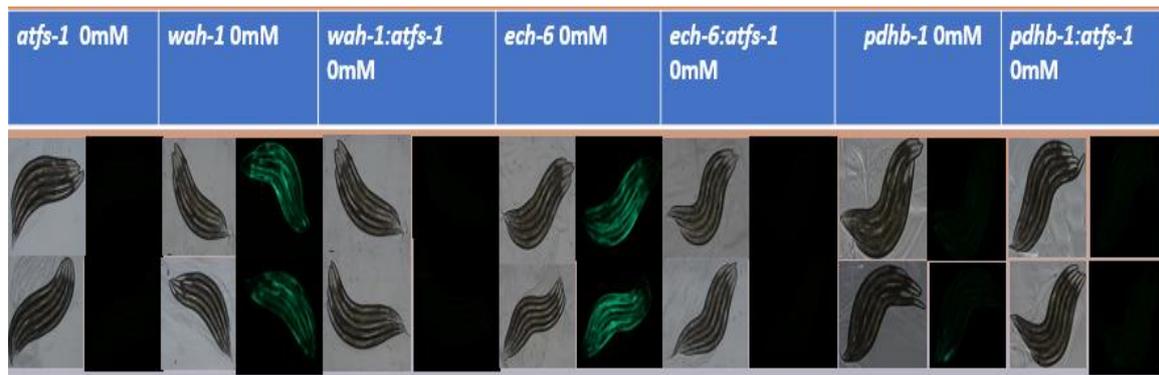


Fig. 4. Representative fluorescence profiles (*hsp-6::gfp*) fed with different RNAi strains at adult day 2 of life as mentioned in the heading.

transcriptional reprogramming that occurs upon UPR<sup>mt</sup> activation. In normal conditions, knockdown of *atfs-1* does not change the lifespan (Fig. 1e, Table 1). But upon metformin treatment, the lifespan was limited to 13.11 days. We further inquired about the loss of UPR<sup>mt</sup> in UPR<sup>mt</sup>-activated worms and used *pdhb-1* fed worms to dissect its effect in lifespan. As expected, double knockdown of *ech-6*, *wah-1*, and *pdhb-1* together with *atfs-1*, completely blocked UPR<sup>mt</sup> as visualized in *hsp-6::gfp* fluorescence profile (Fig. 4). Moreover, double knockdown in *pdhb-1*, also increased the lifespan of worms (17.18 days), comparable to EV (Table 1). However, metformin treatment in these worms proved to be highly toxic and limited lifespan to 13.88 days.

#### 4. Discussion

Metformin has been repurposed to treat variety of disorders and ageing might soon find its place on the list, albeit after the human trial known as TAME (Targeting of aging by Metformin). Metformin extended the lifespan of wildtype worms fed with OP50 and RNAi control vector EV(L4440). The lifespan extension conferred by metformin in our case is less than that of the published articles. This can be attributed to the time point at which the experimental group worms are subjected to the metformin supplemented plate. We supplemented metformin right from the egg stage, directly adapting the method of onken and driscoll. However, more robust, and reproducible lifespan

extension were reported when worms were subjected on metformin laden plates from L4 (4<sup>th</sup> larval stage) or adult day 1 (or day 3 of life) [13, 14]. On the other hand, metformin supplementation during late life (beyond adult day 4) in worms results in significantly decreased lifespan, which is linked with the inability of worms to switch towards dietary restriction like state by enabling the mobilization of stored fats for energy production. Moreover, the concentration of metformin, in *C. elegans* study, is several thousands fold higher in comparison to that of plasma concentrations in human (10  $\mu$ M-40  $\mu$ M) [15]. It is because of the thick cuticle that surrounds the worm body which is highly resistant towards the uptake of polar drugs like metformin and other anti-helminthic drugs [16].

Motivated to study the interaction of metformin and UPR<sup>mt</sup> together with lifespan, we knocked down several genes that invoke UPR<sup>mt</sup>. The confirmation of UPR<sup>mt</sup> activation was performed by using transgenic reporter strain *hsp-6::gfp*. In one of such mutants, *ech-6* (orthologue of mammalian ECHS1), an enzyme functioning in the Branched Chain Amino Acid pathway and fatty acid oxidation, the lifespan was found to be significantly lower than EV. The short lifespan of *ech-6* is causally linked with energy crisis through suppressed mitochondrial function and compromised amino acid catabolism which disables such worms to use stored fats for metabolic homeostasis [17]. Upon knockdown of *ech-6*, there is toxic buildup of acryloyl Co A,

a substrate of ECH-6, which is toxic and highly reactive and therefore results in altered phenotype and reduced lifespan. Also, metformin treatment in N2 (wildtype) has showed the enrichment of BCAA pathway [18]. Considering results and references, we can speculate that *ech-6* might be required for metformin to confer lifespan extension. However, there is dire need of knockout model of *ech-6* validate the results, which to our information has not been generated till this date. In another such UPR<sup>mt</sup>-activating RNAi, *pdhb-1*, which was found to have significantly reduced lifespan (14.40 days). Since, *pdhb-1* is a part of pyruvate dehydrogenase complex, it might generate metabolic crisis upon knockdown and hence change in lifespan. Moreover, the acetyl moiety is required for post translational modifications of several proteins and for the acetylation of histone complex. However, the metformin treatment did not change the lifespan of *pdhb-1* worms. It might hint that metformin might act by decreasing the transcript levels of *pdhb-1*. However, this mechanism should be traced using the whole subunit knockdown of the multienzyme complex of pyruvate dehydrogenase. We further chose *wah-1* (RNAi) as it has extended lifespan unlike *pdhb-1* and *ech-6*. Knockdown of *wah-1*, as previously reported, increased the lifespan of worm, and can be attributed to decrease in the mitochondrial respiration [19]. Upon, metformin treatment the lifespan of worms was decreased, which makes it an essential gene to render metformin induced lifespan extension.

While blocking the UPR<sup>mt</sup>, using *atfs-1* (RNAi), we found that it does not change the lifespan of worms. However, metformin treatment reduced the *atfs-1* lifespan. This effect can be related to the fact that *atfs-1* knockdown limits the mitochondrial biogenesis, causes structural abnormalities in the mitochondrial shape and results in compromised mitochondrial functions [20]. Thus, metformin mediated lifespan might depend upon the number and functional integrity of mitochondria. Knockdown of *atfs-1* caused complete loss of hsp-6::gfp fluorescence in all UPR<sup>mt</sup> activated strains. The lifespan of *pdhb-1;atfs-1*, a double RNAi knockdown mutant,

was found to be rescued. (17.18 days). But, upon metformin treatment, the lifespan was decreased and was limited to 13.88 days. Hence, it was confirmed that UPR<sup>mt</sup> was causal factor in regulating the lifespan in UPR<sup>mt</sup> activated mutants. Owing to the interaction of metformin with UPR<sup>mt</sup>, we found that the drug significantly suppressed the fluorescence profile at different adult hood days in both *ech-6* and *wah-1*. Similar findings were reported by Tan [21] regarding metformin interaction with unfolded protein response in reducing the mitochondrial stress by using in *tom-22* (RNAi). Unlike in our study, metformin suppressed UPR<sup>mt</sup> throughout the lifespan of *tom-22* and significantly extended the lifespan. This might be specific to the gene function (*tom-22*) and its interaction with metformin but also suggests a mechanism that whole life amelioration of mitochondrial stress, other than at specific days, might be required for the lifespan extension. Regarding the mechanism, metformin is known to activate AMPK by phosphorylation and AMPK further decreases the activity of mTOR (mammalian target of rapamycin). Loss of nutrient sensing pathways like mTOR (*let-363*), insulin signaling *daf-2* and increase in mitochondrial membrane potential are found to decrease the expression of hsp-6 [22]. Metformin, therefore, might act through phosphorylated AMPK or might increase the mitochondrial membrane potential to suppress the UPR<sup>mt</sup>.

## 5. Conclusion

Metformin extended the mean and median lifespan of *C. elegans*. In case of UPR<sup>mt</sup> activated mutants, metformin failed to increase the lifespan but suppressed the expression of *hsp-6*. Complete suppression of unfolded protein response using double RNAi knockdown restored the normal lifespan in *pdhb-1*. Our study, therefore, accentuates the regulation of lifespan by UPR<sup>mt</sup> and the necessity of genes *atfs-1*, *wah-1* and *ech-6* for metformin induced lifespan extension.

## Recommendations

This study can be made more comprehensive by employing large number of UPR<sup>mt</sup>-activating

RNAi and assessing its effect under metformin treatment as it will reveal the potential target of metformin. Not only lifespan, but healthspan parameters of worms should also be considered under metformin treatment as longer-lived worms are more likely to expend their larger part of life in frailty.

### Acknowledgements

I would like to thank my major advisor and corresponding author of this manuscript: Asst. Prof. Dr. Wichit Suthammarak for the funding and giving me a complete latitude to conduct this project. I am immensely thankful to our research assistant Chutipong Chiamkunakorn for assisting and accompanying me during lab hours. I am also grateful to Jerald Tan, alumni of our lab, for his guidance and prompt response when inquired. Special thanks to Prof. Bart P. Braekman for sharing the RNAi clones used in the project. Lastly, I am indebted to Siriraj hospital for providing Neighboring country Scholarship.

### References

- [1] Franceschi C, Garagnani P, Morsiani C, Conte M, Santoro A, Grignolio A, et al. The continuum of aging and age-related diseases: common mechanisms but different rates. *Front Med (Lausanne)*. 2018; 5: 61. doi: 10.3389/fmed.2018.00061
- [2] Onken B, Driscoll M. Metformin induces a dietary restriction-like state and the oxidative stress response to extend *C. elegans* Healthspan via AMPK, LKB1, and SKN-1. *PLoS One*. 2010; 5(1): e8758. doi: 10.1371/journal.pone.0008758
- [3] Anisimov VN, Egormin PA, Bershtein LM, Zabezhinskii MA, Piskunova TS, Popovich IG, et al. Metformin decelerates aging and development of mammary tumors in HER-2/neu transgenic mice. *Bull Exp Biol Med*. 2005; 139(6): 721-3. doi: 10.1007/s10517-005-0389-9
- [4] Deschemin JC, Foretz M, Viollet B, Vaulont S. AMPK is not required for the effect of metformin on the inhibition of BMP6-induced hepcidin gene expression in hepatocytes. *Sci Rep*. 2017; 7(1): 12679. doi: 10.1038/s41598-017-12976-2
- [5] Ahmad W, Ebert PR. Metformin attenuates A $\beta$  pathology mediated through levamisole sensitive nicotinic acetylcholine receptors in a *C. elegans* model of alzheimer's disease. *Mol Neurobiol*. 2017; 54(7): 5427-39. doi: 10.1007/s12035-016-0085-y
- [6] Mor DE, Sohrabi S, Kaletsky R, Keyes W, Tartici A, Kalia V, et al. Metformin rescues Parkinson's disease phenotypes caused by hyperactive mitochondria. *Proc Natl Acad Sci U S A*. 2020; 117(42): 26438-47. doi: 10.1073/pnas.2009838117
- [7] Sanchis A, Garcia-Gimeno MA, Cañada-Martinez AJ, Sequedo MD, Millan JM, Sanz P, et al. Metformin treatment reduces motor and neuropsychiatric phenotypes in the zQ175 mouse model of Huntington disease. *Exp Mol Med*. 2019; 51(6): 1-16. doi: 10.1038/s12276-019-0264-9
- [8] Kaushik S, Cuervo AM. Proteostasis and aging. *Nat Med*. 2015; 21(12): 1406-15. doi: 10.1038/nm.4001
- [9] Nargund AM, Pellegrino MW, Fiorese CJ, Baker BM, Haynes CM. Mitochondrial import efficiency of ATFS-1 regulates mitochondrial UPR activation. *Science*. 2012; 337(6094): 587-90. doi: 10.1126/science.1223560
- [10] Bennett CF, Vander Wende H, Simko M, Klum S, Barfield S, Choi H, et al. Activation of the mitochondrial unfolded protein response does not predict longevity in *Caenorhabditis elegans*. *Nat Commun*. 2014; 5(1): 3483. doi: 10.1038/ncomms4483
- [11] Andrzejewski S, Gravel SP, Pollak M, St-Pierre J. Metformin directly acts on mitochondria to alter cellular bioenergetics. *Cancer Metab*. 2014; 2: 12. doi: 10.1186/2049-3002-2-12
- [12] Yang JS, Nam HJ, Seo M, Han SK, Choi Y, Nam HG, et al. OASIS: online application for the survival analysis of lifespan assays performed in aging research. *PLoS One*. 2011; 6(8): e23525. doi: 10.1371/journal.pone.0023525
- [13] Cabreiro F, Au C, Leung KY, Vergara-Irigaray N, Cochemé HM, Noori T, et al. Metformin retards aging in *C. elegans* by altering microbial folate and methionine metabolism. *Cell*. 2013; 153(1): 228-39. doi: 10.1016/j.cell.2013.02.035
- [14] Chen J, Ou Y, Li Y, Hu S, Shao LW, Liu Y. Metformin extends *C. elegans* lifespan through lysosomal pathway. *Elife*. 2017; 6. doi: 10.7554/eLife.31268

- [15] LaMoia TE, Shulman GI. Cellular and molecular mechanisms of metformin action. *Endocr Rev.* 2021; 42(1): 77-96. doi: 10.1210/edrv/bnaa023
- [16] Burns AR, Luciani GM, Musso G, Bagg R, Yeo M, Zhang Y, et al. *Caenorhabditis elegans* is a useful model for anthelmintic discovery. *Nat Commun.* 2015; 6: 7485. doi: 10.1038/ncomms8485
- [17] Liu YJ, Gao AW, Smith RL, Janssens GE, Panneman DM, Jongejan A, et al. Reduced ech-6 expression attenuates fat-induced lifespan shortening in *C. elegans*. *Sci Rep.* 2022; 12(1): 3350. doi: 10.1038/s41598-022-07397-9
- [18] De Haes W, Froominckx L, Van Assche R, Smolders A, Depuydt G, Billen J, et al. Metformin promotes lifespan through mitohormesis via the peroxiredoxin PRDX-2. *Proc Natl Acad Sci U S A.* 2014; 111(24): E2501-9. doi: 10.1073/pnas.1321776111
- [19] Troulinaki K, Buttner S, Marsal Cots A, Maida S, Meyer K, Bertan F, et al. WAH-1/AIF regulates mitochondrial oxidative phosphorylation in the nematode *Caenorhabditis elegans*. *Cell Death Discov.* 2018; 4(1): 2. doi: 10.1038/s41420-017-0005-6
- [20] Shpilka T, Du Y, Yang Q, Melber A, Uma Naresh N, Lavelle J, et al. UPR(mt) scales mitochondrial network expansion with protein synthesis via mitochondrial import in *Caenorhabditis elegans*. *Nat Commun.* 2021; 12(1): 479. doi: 10.1038/s41467-020-20784-y
- [21] Tan J, Boonchuay K, Suthammarak W. Effect of metformin on lifespan and unfolded protein responses in *Caenorhabditis elegans*. In: *Proceeding of Graduate Research Forum 2020: An Academic Conference for Graduate Student; 2020 May 12-19.*
- [22] Haeussler S, Köhler F, Witting M, Premm MF, Rolland SG, Fischer C, et al. Autophagy compensates for defects in mitochondrial dynamics. *PLoS Genet.* 2020; 16(3): e1008638. doi: 10.1371/journal.pgen.1008638

# Effectiveness of Palliative Learning Model Based on Transformational Learning Theory on the Achievement of Nursing Student' Competency

Ni Luh Putu Inca Buntari Agustini <sup>a, b</sup>, Nursalam Nursalam <sup>a, \*</sup>, Tintin Sukartini <sup>a</sup>

<sup>a</sup> Faculty of Nursing, Universitas Airlangga, Surabaya, Indonesia

<sup>b</sup> Faculty of Health, Institute of Technology and Health Bali, Denpasar, Indonesia

## Abstract

**Background:** The problem faced by nursing students is the achievement of nursing students' competence which is found to be less than optimal. One of the obstacles identified as the cause is that the learning model applied is still using the traditional conventional model. Palliative care requires implementing a learning model that emphasizes authentic relationships. Therefore, it is necessary to implement learning that prioritizes authentic relationships. This study aims to see the effectiveness of the palliative learning model based on transformational learning theory to increase nursing students' competencies in palliative care.

**Method:** The study was conducted quasi-experimental with a control group design. The total sample of 52 students for each group. The variables in this study were the TLT-based palliative learning module and nursing students' competencies. The instrument used was a TLT-based palliative learning module and Nursing Student Competency Achievement questionnaire. Data collection was carried out in September 2021-February 2022 online via media zoom, WhatsApp groups and Google forms, beginning with a pre-test in both groups. The intervention was carried out by implementing the teaching and learning process using TLT-based palliative learning and practicum modules for 14 meetings and conventional learning modules for the control group. The statistical test used Generalized Linear Models Repeated Measure (GLM-RM). This research has received ethical approval from the ethics committee.

**Results:** The respondent's characteristic was at the age of 19 years, namely 30 (57.7%), women 45 (86.5%). The highest proportion of religion was Hinduism 47 (90.4%). The socio-cultural background was Balinese cultural background, which is 50 (96.5%). Most parents' occupations were self-employed, namely 18 (34.6%). The results showed an effect of applying the TLT-based palliative learning module on the achievement of nursing students' competence in palliative care ( $p=0.000$ ).

**Conclusion:** The application of the TLT-based palliative learning module has been proven to increase competency achievement for nursing students in palliative care. Learning media and competencies regarding palliative care can contribute to increasing the achievement of nursing students' competencies in palliative care.

**Keywords:** Clinical competency, Learning, Nursing students, Palliative

## 1. Introduction

One of the competencies that nurses must possess is performing holistic palliative care. The problem encountered is that students' knowledge is still lacking, impacting attitudes and skills when caring for patients who need palliative care [1]. The data shows that the achievement of

student competence after participating in palliative learning shows that the majority of 189 students (75.7%) have a low level of knowledge about palliative care. Fourteen (5.4%) students had negative attitudes, and 42 (14.8%) had poor skills regarding palliative care. Judging from the aspect of the final value of the palliative nursing course

\* Corresponding author.

E-mail address: [nursalam@fkp.unair.ac.id](mailto:nursalam@fkp.unair.ac.id) (Nursalam Nursalam)

This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>)

obtained from 191 students in 2019, the majority of 176 (92.14%) students scored in the 68-80 range, and there were still those who scored in the 56-67.9 range, which is 5.7%. The results of the study of 240 nursing students who had received palliative nursing courses, 235 (98%) students, revealed that the majority of the learning models used the conventional model with the lecture method 147 (61.3%) and discussion 88 (36.7%) [2].

Palliative care always discusses chronic, incurable diseases, dying patients, uncertainty, loss, grief, death, and grieving [3, 4]. This condition requires high self-confidence and authentic relationship [5]. Inadequate knowledge can cause students to have negative attitudes and be less competent when caring for patients with palliative care needs with different care complexities [6-8]. Currently, palliative learning is still applying conventional learning models, most of which use the question-and-answer lecture method [9]. The weakness of the traditional learning model is that it still focuses on the passive transfer of objective knowledge from educators to students [10]. Therefore, it is necessary to conduct research using Transformational Learning Theory (TLT)-based learning to support the success rate of palliative learning. TLT is adult learning using pre-owned life experiences in the form of perspectives, habits of mind, and mindsets to make it more inclusive, discriminatory, open, and reflective so that it can generate beliefs and opinions that will prove to be justified as a guide in taking action [11, 12]. The advantage of TLT is high flexibility, and learning can be done anywhere and anytime [13]. This study aimed to determine the effectiveness of transformational learning theory-based palliative learning modules on increasing the competence of nursing students regarding holistic palliative care.

## 2. Methods

This study uses a quasi-experimental design with a pre-post-test control group design to see the effectiveness of transformational learning theory-based palliative education media. The sample in this study was determined by simple random sampling, with a total number of

respondents of 52 for each group. The variables in this study were the TLT-based palliative learning module as the independent variable and nursing students' competencies as the dependent variable. To measure nursing students' competency achievement in palliative care TLT-based palliative learning module and Nursing Student Competency Achievement questionnaire were compiled and developed based on research conducted in the previous stage. This instrument has been standardized with validity and reliability tests. Data was collected online from September 2021-February 2022 through zoom media, WhatsApp groups and Google forms, beginning with explaining the informed consent form and conducting a pre-test using palliative learning instruments in the treatment and control groups. The intervention was carried out by implementing the teaching and learning process for 14 theoretical and 14 practical meetings. Each theoretical meeting is given two times/week with a total time of 250 minutes, and the practicum is carried out every day for 170 minutes.

The treatment group took part in PBM using TLT-based palliative learning modules. Practicum modules include basic concepts of palliative care, effective communication in palliative care, ethics and legal principles in palliative care, professional nursing practice in palliative, leadership and management in palliative care, education and research in palliative care, professional, personal, and quality development in palliative care. While the control group took part in PBM using conventional learning modules according to what had been implemented before. Palliative learning competency achievement was evaluated every four weeks. The statistical analysis using Generalized Linear Models Repeated Measure (GLM-RM). The statistical test This research has received ethical approval from the ethics committee.

## 3. Results

Assessment of the description of the characteristics of respondents based on the results of descriptive analysis is presented in the form of a frequency distribution table in the form of percentage and frequency values, mean values,

Table 1. Equality test of respondents' characteristics between treatment groups and control groups.

Variables	Experiment Group		Control Group		p-value
	n	%	n	%	
<b>Age</b>					
19	30	57.7	22	42.3	0.139
20	22	42.3	28	53.8	
21	0	0.0	2	3.8	
<b>Gender</b>					
Female	45	86.5	43	82.7	0.587
Male	7	13.5	9	17.3	
<b>Religion</b>					
Hindu	47	90.4	46	88.5	0.317
Islam	3	5.8	1	1.9	
Catholic	2	3.8	5	9.6	
<b>Ethnic</b>					
Balinese	50	96.2	50	96.2	0.135
Javanese	0	0.0	2	3.8	
Lomboknese	2	3.8	0	0.0	
<b>Parent occupation</b>					
No work	0	0.0	2	3.8	0.093
Self-employees	18	34.6	26	50.0	
Private employees	14	26.9	10	19.2	
Civil employees	12	23.1	10	19.2	
Farmer	0	0.0	5	9.6	
Pensionary	3	5.8	4	7.7	
<b>Experience of loss</b>					
Yes	44	84.6	37	71.2	0.098
No	8	15.4	15	28.8	
<b>Experience of grief</b>					
Yes	47	90.4	42	80.8	0.163
No	5	9.6	10	19.2	
<b>Experience of bereavement</b>					
Yes	40	76.9	37	71.2	0.502
No	12	23.1	15	28.8	
<b>Experience in treating chronic disease</b>					
Yes	20	38.5	26	50.0	0.236
No	32	61.5	26	50.0	
<b>Experience in treating the end of life</b>					
Yes	17	32.7	13	25.0	0.387
No	35	67.3	39	75.0	
<b>Interest in palliative care</b>					
Yes	51	98.1	50	96.2	0.558
No	1	1.9	2	3.8	

and standard deviations. The results of the homogeneity test from the analysis of the characteristics of the respondents can reveal a general description of the respondent's background, including age, gender, socio-cultural background,

parents' occupation, past experiences of loss, grief, and bereavement. The experience of caring for patients with chronic diseases and nearing the end of life, as well as the interest of nursing students in palliative nursing courses. The following are

Table 2. Competency achievement between treatment groups and control groups before and after intervention

Competencies Achievement			t-statistic	Sig. (2-tailed)
Pre-test	Treatment	2.639±0.103	0.422	0.674
	Control	2.647±0.090		
Post-test 1	Treatment	2.977±0.098	-13.363	0.000
	Control	2.735±0.086		
Post-test 2	Treatment	3.111±0.121	-9.338	0.000
	Control	2,904±0.104		
Post-test 3	Treatment	3.243±0.121	-10.512	0.000
	Control	2.978±0.135		
Post-test 4	Treatment	3.487±0.094	-20.936	0.000
	Control	3.030±0.125		
Post-test 5	Treatment	3.712±0.149	-21.994	0.000
	Control	3.147±0.108		

the results of the equality test of respondents' characteristics between the treatment group and the control group before being given the intervention.

Table 1 shows that the highest proportion in the treatment group was at the age of 19 years, namely 30 (57.7%), while the control group had the highest balance at the age of 20 years, which was 28 (53.8%). The sex of the respondents in the treatment group and the control group were primarily women, 45 (86.5%) in the treatment group and 43 (82.7%) in the control group. The highest proportion of religion in both groups was Hinduism, namely in the treatment group 47 (90.4%) and in the control group 46 (88.5%). The socio-cultural background in the two groups has the highest proportion of Balinese cultural background, which is 50 (96.5%) in both the treatment and control groups. Most parents' occupations in both groups were self-employed, namely in the treatment group 18 (34.6%) and in the control group 26 (50%).

The highest proportion in the treatment and control groups has past experiences of loss, grief, and bereavement. In the treatment group, the ratio of having experienced loss was 44 (84.6%) and 37 (71.2%) in the control group. The proportion of having past experiences of grief in the treatment group was 47 (90.4%), and in the control group was 42 (80.8%). The proportion of having past experiences of grief in the treatment

group was 40 (76.9%), and in the control group was 37 (71.2%). The treatment group had the highest proportion of having no experience caring for patients with chronic diseases, 32 (61.5%). In the control group, the balance between having experience and not having experience caring for patients with chronic diseases was 26 (50%).

The highest proportion in both groups was that who had never experienced end-of-life care, which was 35 (67.3%) in the treatment group and 39 (75%) in the control group. The two groups had the highest interest in attending palliative nursing courses: the admission group, 51 (98.1%), and the control group, 50 (96.2%). The chi-square test results show no difference in the characteristics of the respondents with a p-value > 0.05, which means that the aspects between the treatment group and the control group are equivalent.

Based on Table 2, the results of the independent sample t-test show that there is no significant difference between the competency achievements, which include: 1) the physical aspect of care, 2) the psychological aspect of care, 3) the social-cultural aspect of care, 4) spiritual aspect of care, and 5) care of the patient at the end-of-life before intervention between the treatment group and the control group (p=0.674). On the other hand, there was a significant difference in the competency achievement variable after being given an intervention starting from posttest 1-5 (p=0.000).

Table 3. Student competency achievements in the physical aspect of care domain before and after intervention of transformational learning theory-based palliative learning models.

Variables	Experimental Group			Control Group			p-value	R <sup>2</sup>
	Mean±SD	Δ(%)	95% CI	Mean±SD	Δ(%)	95% CI		
<b>The physical aspect of care</b>								
Pre-test	2.73±0.06	-	2.62-2.85	2.83±0.06	-	2.71-2.94	0.242	0.556
Post-test 1	3.00±0.04	9.89	2.92-3.08	2.87±0.04	1.41	2.79-2.94	0.016	0.459
Post-test 2	3.08±0.05	2.67	2.98-3.17	2.96±0.05	3.14	2.87-3.05	0.084	0.459
Post-test 3	3.10±0.04	0.65	3.01-3.18	2.98±0.04	0.68	2.90-3.07	0.057	0.451
Post-test 4	3.44±0.06	10.97	3.33-3.55	3.04±0.06	2.01	2.93-3.15	0.000	0.504
Post-test 5	3.83±0.06	11.34	3.72-3.94	3.15±0.06	3.62	3.04-3.26	0.000	0.459
<b>The psychological aspect of care</b>								
Pre-test	2.71±0.06	-	2.59-2.83	2.77±0.06	-	2.65-2.89	0.507	0.529
Post-test 1	3.00±0.04	10.70	2.92-3.08	2.87±0.04	3.61	2.79-2.94	0.016	0.483
Post-test 2	3.06±0.04	2.00	2.98-3.13	2.94±0.04	2.44	2.87-3.02	0.034	0.461
Post-test 3	3.17±0.04	3.59	3.09-3.25	2.98±0.04	1.36	2.90-3.06	0.001	0.461
Post-test 4	3.48±0.06	9.78	3.37-3.59	3.08±0.06	3.36	2.97-3.19	0.000	0.504
Post-test 5	3.79±0.05	8.91	3.69-3.89	3.10±0.05	0.65	3.00-3.20	0.000	0.363
<b>Social/cultural aspect of care</b>								
Pre-test	2.67±0.06	-	2.55-2.8	2.75±0.06	-	2.63-2.88	0.392	0.496
Post-test 1	3.00±0.04	12.36	2.93-3.07	2.90±0.04	5.45	2.83-2.97	0.055	0.464
Post-test 2	3.04±0.03	1.33	2.97-3.1	2.96±0.03	2.07	2.90-3.03	0.104	0.575
Post-test 3	3.27±0.05	7.57	3.17-3.37	2.92±0.05	-1.35	2.82-3.03	0.000	0.468
Post-test 4	3.54±0.06	8.26	3.42-3.65	3.02±0.06	3.42	2.90-3.13	0.000	0.521
Post-test 5	3.79±0.05	7.06	3.69-3.89	3.10±0.05	2.65	3.00-3.20	0.000	0.256
<b>Spiritual Aspect of Care</b>								
Pre-test	2.67±0.07	-	2.55-2.80	2.71±0.07	-	2.58-2.84	0.675	0.540
Post-test 1	3.02±0.05	13.11	2.93-3.11	2.81±0.05	3.69	2.72-2.90	0.001	0.557
Post-test 2	3.06±0.03	1.32	2.99-3.12	2.94±0.03	4.63	2.88-3.01	0.014	0.643
Post-test 3	3.17±0.04	3.59	3.09-3.25	3.02±0.04	2.72	2.94-3.10	0.007	0.585
Post-test 4	3.40±0.06	7.26	3.29-3.52	3.02±0.06	0.00	2.91-3.13	0.000	0.657
Post-test 5	3.73±0.06	9.71	3.62-3.84	3.14±0.06	3.97	3.03-3.25	0.000	0.476
<b>Care of Patients at the End-of-Life</b>								
Pre-test	2.83±0.06	-	2.71-2.94	2.71±0.06	-	2.60-2.83	0.166	0.974
Post-test 1	3.00±0.04	6.01	2.92-3.08	2.87±0.04	5.90	2.79-2.94	0.016	0.788
Post-test 2	3.12±0.04	4.00	3.03-3.20	2.92±0.04	1.74	2.84-3.01	0.001	0.788
Post-test 3	3.12±0.05	0.00	3.02-3.21	3.02±0.05	3.42	2.92-3.12	0.161	0.755
Post-test 4	3.48±0.06	11.54	3.37-3.60	2.98±0.06	-1.32	2.87-3.10	0.000	0.755
Post-test 5	3.77±0.05	8.33	3.67-3.87	3.10±0.05	4.03	3.00-3.20	0.000	0.667

Based on Table 3 showed that the results of the statistical tests. R<sup>2</sup> (R square) value shows the strength of the difference from each posttest. There were differences in competency achievement in the physical aspect of care at the time posttest (p=0.016) with a power of 45.9% difference, the posttest (p=0.000) with a strength of 50.4% difference, and posttest the fifth with a power difference of 45.9%. The results of the analysis of differences in competency achievement

in the physical aspect of care between measurements before being given an intervention until after being given an intervention (posttest 1, 4, and 5) between the treatment group and the control group (p<0.05) with a power difference of 72.7%. Competency achievement in the psychological aspect of care at the time posttest (p=0.016) with a strength of difference of 48.3%, posttest (p=0.034) with a force of difference of 46.1%, the posttest (p=0.000) with a strength of

difference of 46.1%, posttest fourth ( $p=0.000$ ) with a power of difference of 50.4%, and posttest the fifth there is a difference in competency achievement in the social/cultural aspect of care at the posttest ( $p=0.000$ ) with a strength of 46.8% difference, the posttest ( $p=0.000$ ) with a power of 52.1% difference, and posttest the fifth difference 25.6. There is a difference in competency achievement in the spiritual aspect of care at the time posttest ( $p=0.001$ ) with a substantial difference of 55.7%, posttest ( $p=0.014$ ) with a significant difference of 64.3%, the posttest ( $p=0.007$ ) with a considerable difference of 58.5%, posttest ( $p=0.000$ ) with a power of difference of 65.7%, and posttest ( $p=0.000$ ) with a power of difference of 47.6%. There was a difference in competency achievement in the domain of care of the patient at the end-of-life at the time posttest ( $p=0.016$ ) with a power of 78.8% difference, posttest ( $p=0.001$ ) with a power of 78.8% difference, posttest the fourth) with a power of difference of 75.5%, and posttest ( $p=0.000$ ) with a power of difference of 66.7%.

Based on the results of the GLM-RM test for each competency achievement, it can be seen that after the fourth and fifth lessons were given, there was an increase in the best competency achievement in all domains of palliative care competency achievement.

#### 4. Discussion

A significant difference in the achievement of nursing students' competence in holistic palliative care increased after being given a TLT-based palliative learning module. Students who received the palliative learning module and the TLT-based palliative practicum module showed a significant increase in achieving holistic palliative care competencies. By identifying the factors that influence learning, the learning model approach has proven to be effective in increasing the achievement of nursing students' competencies regarding palliative care [14]. Basic competence in palliative care provides the basis for general palliative care in all health facilities [15]. Compassionate, competent, and culturally sensitive care is at the core of the competence of palliative

nursing (Palliative Nursing Care) [16].

The achievements of palliative care competencies are assessed in the cognitive, affective, and psychomotor domains, including physical aspects of care, psychological aspects of care, social/cultural aspects of care, spiritual aspects of care, and care of the patient at the end of life [17]. Assessment physical part of care includes the ability to perform disease management, assess pain complaints and other physical symptoms, assess physical function abilities, assess nutritional needs habits, and evaluate physical activity [8, 18]. Assessment of the psychological aspect of care competence includes the ability to assess personality, assess psychological symptoms experienced by patients, assess patient's emotional level, assess patient control and dignity, assess patient's coping mechanisms, assess self-image, and assess patient's loss or grief [19, 20]. Social and cultural aspects of care competence include identifying the patient's finances, maintaining professional relationships, reviewing personal routines, recreational needs, patient work, patient routine habits, legal issues, and family care support [21]. The spiritual competence aspect of care includes conducting spiritual assessments covering religious, spiritual, and existential issues [22]. The ability to refer patients and families in severe conditions by presenting clergy and priests if needed [23]. Evaluation competence of care of the patient at the end of life includes the ability to recognize the signs and symptoms of the patient's death, the ability to ensure comfort at the end of life, the ability to review cultural, religious, and customary rituals in dealing with the patient's death, the ability to provide post-death support to families who abandoned and the ability to carry out corpse care according to the culture, customs and religion of the patient [24].

Domain physical aspect of care has less than optimal results. It is possible that students are less interested in material about the physical aspect of care, impacting they are less than optimal skills in practising the physical aspect of care [25]. The age of the students influences the achievement of competence in the physical aspect of care [26]. Younger students have less confidence in taking

care of the physical aspect, while older students have high confidence in performing palliative care on the physical aspect [27].

The most optimal student competency achievement is in the domain of the psychological aspect of care and spiritual aspect of care. Positive mediators psychologically affect students' mental readiness to carry out palliative care and care before death [28]. The positive mediators in question are students' personal life experiences, including past experiences of loss, grief, and bereavement, experiences of caring for patients with chronic diseases, and experiences of caring for family or close friends near death [1]. Age, gender, socio-cultural and religious factors also positively impact students' attitudes and skills in dealing with patients who need palliative care and care before death [29]. This study's results align with previous research, which revealed that an interest influences students' readiness to achieve learning competencies in participating in learning, interest in learning topics/materials, and prior experiences following the material provided. Social/cultural and religious factors can also influence the positive perspective of students in participating in learning so that it has an impact on positive knowledge and attitudes as well as students' skills in holistic palliative care [30, 31].

Competence is a holistic combination of knowledge, skills, experience, qualities, characteristics, and attitudes to effectively perform a job or task [32]. Professional competence in palliative care can be achieved by increasing knowledge, attitudes, and skills in the classroom and laboratory [33]. Facing the real world when they graduate, students must have superior competencies, especially in palliative care. Particular attention can be paid to positive mediating factors that significantly affect the achievement of palliative and near-death care competencies. The achievement of still lacking competencies can be used as evaluation material for further learning.

The novelty from the theoretical side is the integration of new material on leadership and management in palliative care, education, and research in palliative care, and professional, personal, and quality development in palliative

care adapted from 5 (five) domains of the ASEAN nursing common core competencies that have been determined through KMK No. HK.01.07/MENKES/425/2020 concerning standards for the nursing profession [34]. TLT-based palliative learning is defined as a learning model that involves students as learning subjects (student centre learning) to increase students' independence in participating in learning (self-directed learning) through four phases of TLT, namely: disorienting dilemma, critical self-reflection, reflective discourse, and integrated action involving students with creative and innovative learning modes that can develop critical cognitive aspects, positive attitudes, creative and constructive skills to experience increased nursing competency outcomes palliative.

## 5. Conclusion

The palliative learning model developed through the integration of transformational learning theory by involving learning components including student characteristics factors, educator characteristics factors, previously possessed competencies about palliative care, and learning media has proven to be able to contribute to increasing the achievement of nursing students' competencies regarding holistic palliative care. Raising the achievement of students' competence in holistic palliative care can be met by implementing a transformational learning theory-based learning model that puts forward the principle of authentic relationship and is adjusted to the development needs and educational views of the competence of palliative care.

## References

- [1] Jiang Q, Lu Y, Ying Y, Zhao H. Attitudes and knowledge of undergraduate nursing students about palliative care: An analysis of influencing factors. *Nurse Educ Today*. 2019; 80: 15-21. doi: 10.1016/j.nedt.2019.05.040
- [2] Agustini NLP, Nursalam N, Rismawan M, Faridah VN. Undergraduate nursing students' knowledge, attitude and practice toward palliative care in Indonesia: A cross-sectional online survey. *Int J Psychosoc Rehabil*. 2020;

- 24(7): 7707-17. doi: 10.37200/IJPR/V24I7/PR270741
- [3] Blazin LJ, Cecchini C, Habashy C, Kaye EC, Baker JN. Communicating effectively in pediatric cancer care: translating evidence into practice. *Children (Basel)*. 2018; 5(3): 40. doi: 10.3390/children5030040
- [4] Pooler C, Richman-Eisenstat J, Kalluri M. Early integrated palliative approach for idiopathic pulmonary fibrosis: A narrative study of bereaved caregivers' experiences. *Palliat Med*. 2018; 32(9): 1455-64. doi: 10.1177/0269216318789025
- [5] Krautheim V, Schmitz A, Benze G, Standl T, Schiessl C, Waldeyer W, et al. Self-confidence and knowledge of German ICU physicians in palliative care - a multicentre prospective study. *BMC Palliat Care*. 2017; 16(1): 57. doi: 10.1186/s12904-017-0244-6
- [6] Farmani AH, Mirhafez SR, Kavosi A, Moghadam Pasha A, Jamali Nasab A, Mohammadi G, et al. Dataset on the nurses' knowledge, attitude and practice towards palliative care. *Data Brief*. 2019; 22: 319-25. doi: 10.1016/j.dib.2018.11.133
- [7] Miltiades HB. University Students' Attitudes Toward Palliative Care. *Am J Hosp Palliat Care*. 2020; 37(4): 300-4. doi: 10.1177/1049909119876911
- [8] Thrane SE. Online Palliative and End-of-Life Care Education for Undergraduate Nurses. *J Prof Nurs*. 2020; 36(1): 42-6. doi: 10.1016/j.profnurs.2019.07.002
- [9] Shaw PA, Abbott MA. High-fidelity simulation: Teaching end-of-life care. *Nurse Educ Today*. 2017; 49: 8-11. doi: 10.1016/j.nedt.2016.10.014
- [10] Wesley LTW, Bin Mohamad Ikbal MF, Jingting W, Taufeeq Wahab M, Teng YC. Towards a practice guided evidence based theory of mentoring in palliative care. *J Palliat Care Med*. 2017; 7(1): 296. doi: 10.4172/2165-7386.1000296
- [11] Christie M, Carey M, Robertson A, Grainger P. Putting transformative learning theory into practice. *Australian Journal of Adult Learning*. 2015; 55(1): 9-30.
- [12] Nohl A-M. Typical phases of transformative learning: a practice-based model. *Adult Educ Q*. 2015; 65(1): 35-49. doi: 10.1177/0741713614558582
- [13] Kegan R. What "form" transforms?: A constructive-developmental approach to transformative learning. In: Illeris K, editor. *Contemporary theories of learning*. London: Routledge; 2018. p. 29-45.
- [14] Suikkala A, Tohmola A, Rahko EK, Hokka M. Future palliative competence needs - a qualitative study of physicians' and registered nurses' views. *BMC Med Educ*. 2021; 21(1): 585. doi: 10.1186/s12909-021-02949-5
- [15] Giezendanner S, Jung C, Banderet HR, Otte IC, Gudat H, Haller DM, et al. General practitioners' attitudes towards essential competencies in end-of-life care: A cross-sectional survey. *PLoS One*. 2017; 12(2): e0170168. doi: 10.1371/journal.pone.0170168
- [16] Davis A, Lippe M, Burduli E, Barbosa-Leiker C. Development of a new undergraduate palliative care knowledge measure. *J Prof Nurs*. 2020; 36(1): 47-52. doi: 10.1016/j.profnurs.2019.06.007
- [17] Wang Q, Chan IKW, Lou VWQ. Effectiveness of a holistic capacity-building program for volunteers in community-based end-of-life care. *Res Soc Work Pract*. 2020; 30(4): 408-21. doi: 10.1177/1049731519898530
- [18] Pawlow P, Dahlin C, Doherty CL, Ersek M. The hospice and palliative care advanced practice registered nurse workforce: Results of a national survey. *J Hosp Palliat Nurs*. 2018; 20(4): 349-57. doi: 10.1097/NJH.00000000000000449
- [19] Clark D, Baur N, Clelland D, Garralda E, Lopez-Fidalgo J, Connor S, et al. Mapping levels of palliative care development in 198 countries: The situation in 2017. *J Pain Symptom Manage*. 2020; 59(4): 794-807 e4. doi: 10.1016/j.jpainsymman.2019.11.009
- [20] Inbadas H, Carrasco JM, Clark D. Representations of palliative care, euthanasia and assisted dying within advocacy declarations. *Mortality (Abingdon)*. 2020; 25(2): 138-50. doi: 10.1080/13576275.2019.1567484
- [21] Thana K, Lehto R, Sikorskii A, Wyatt G. Informal caregiver burden for solid tumour cancer patients: a review and future directions. *Psychol Health*. 2021; 36(12): 1514-35. doi: 10.1080/08870446.2020.1867136
- [22] Harrad R, Cosentino C, Keasley R, Sulla F. Spiritual care in nursing: an overview of the measures used to assess spiritual care provision and related factors amongst nurses. *Acta Biomed*. 2019; 90(4-s): 44-55. doi: 10.23750/abm.v90i4-S.8300

- [23] Lai XB, Wong FKY, Ching SSY. The experience of caring for patients at the end-of-life stage in non-palliative care settings: a qualitative study. *BMC Palliat Care*. 2018; 17(1): 116. doi: 10.1186/s12904-018-0372-7
- [24] Schram AW, Hougham GW, Meltzer DO, Ruhnke GW. Palliative care in critical care settings: A systematic review of communication-based competencies essential for patient and family satisfaction. *Am J Hosp Palliat Care*. 2017; 34(9): 887-95. doi: 10.1177/1049909116667071
- [25] DePietro DM, Santucci SE, Harrison NE, Kiefer RM, Trerotola SO, Sudheendra D, et al. Medical student education during the Covid-19 pandemic: initial experiences implementing a virtual interventional radiology elective course. *Acad Radiol*. 2021; 28(1): 128-35. doi: 10.1016/j.acra.2020.10.005
- [26] Ivera-Burciaga AR, Palacios M, Kemery SA. Educating for equity in palliative care: Implications of the Future of Nursing 2030 Report. *J Prof Nurs*. 2022; 42: 134-9. doi: 10.1016/j.profnurs.2022.06.012
- [27] Colley SL. Senior nursing students' perceptions of caring for patients at the end of life. *J Nurs Educ*. 2016; 55(5): 279-83. doi: 10.3928/01484834-20160414-07
- [28] Paal P, Brandstötter C, Lorenzl S, Larkin P, Elsner F. Postgraduate palliative care education for all healthcare providers in Europe: Results from an EAPC survey. *Palliat Support Care*. 2019; 17(5): 495-506. doi: 10.1017/s1478951518000986
- [29] Bennardi M, Diviani N, Saletti P, Gamondi C, Stüssi G, Cinesi I, et al. A qualitative analysis of educational, professional and socio-cultural issues affecting interprofessional collaboration in oncology palliative care. *Patient Educ Couns*. 2022; 105(9): 2976-83. doi: 10.1016/j.pec.2022.05.006
- [30] Dimoula M, Kotronoulas G, Katsaragakis S, Christou M, Sgourou S, Patiraki E. Undergraduate nursing students' knowledge about palliative care and attitudes towards end-of-life care: A three-cohort, cross-sectional survey. *Nurse Educ Today*. 2019; 74: 7-14. doi: 10.1016/j.nedt.2018.11.025
- [31] Hristova I. Assessment of skills and competencies of nurse students. *Journal of IMAB - Annual Proceeding (Scientific Papers)*. 2021; 27(3): 3968-72. doi: 10.5272/jimab.2021273.3968
- [32] Hokka M, Martins Pereira S, Polkki T, Kyngas H, Hernandez-Marrero P. Nursing competencies across different levels of palliative care provision: A systematic integrative review with thematic synthesis. *Palliat Med*. 2020; 34(7): 851-70. doi: 10.1177/0269216320918798
- [33] Harden K, Price D, Duffy E, Galunas L, Rodgers C. Palliative care: Improving nursing knowledge, attitudes, and behaviors. *Clin J Oncol Nurs*. 2017; 21(5): E232-e8. doi: 10.1188/17.Cjon.E232-e238
- [34] Kemenkes RI. Standar Profesi Perawat: Keputusan Menteri Kesehatan No. HK. 01.07-Menkes-425-2020 tentang Standar Profesi Perawat. Jakarta: Kementerian Dalam Negeri; 2020.

