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Kesmas

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(National Public Health Journal)

Quarterly Journal

Nationally accredited and indexed in SINTA-S1 by Ministry of Education and Culture of the Republic of Indonesia & SCOPUS coverage years from 2016 - present

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READER MAIL

Dear Editorial Team, Authors, Viewers, Subscribers, and Readers

I am very pleased to read the articles in Volume 18, Issue 3, August 2023. Unfortunately, even though the World Health Organization has declared the end of the COVID-19 pandemic as a Public Health Emergency of International Concern, most articles published in the latest issue still discuss the COVID-19 pandemic, which I think is somehow outdated and irrelevant. I wish the articles in the next issue could cover the updated issues like climate change or air pollution since I saw my friends often updated about Jakarta being the worst air quality country recently in their social media. By reading the articles about current climate change and air pollution issues, I hope to find a solution or at least a way to live my daily life but still stay healthy. **(Nurul, Jakarta)**

INFORMATION

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    - Book :
      Grech ED. ABC of interventional cardiology. 2nd ed. Chichester: Wiley blackwell; 2011. Available from: https://ebookcentral.proquest.com/lib/imperial/detail.action?docID=822522
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      Pullen LC. Antibiotic resistance continues to be a problem in children. Medscape; 2017. Available from: https://www.medscape.com/viewarticle/860801
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Asyary, *et al. Kesmas: Jurnal Kesehatan Masyarakat Nasional (National Public Health Journal)*. 2023; 18 (4): 215-216
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Editorial: The Public Health Scholars as the Health Leaders

Dear Colleagues,

Thinking over public health, we believe there are many ways to determine it. For instance, a majority perspective can be underpinned by two keywords: science and art, by its approach to health in the community.[1,2] Therefore, we would like to invite all of you, each of our colleagues, to recall the "true color" of public health scholars in the present issue of Kesmas. In Volume 18, Issue 4, November 2023, the last issue of the year, Kesmas emphasizes current substantial topics that apply as public health implications as approaches and interventions to mitigate global issues, particularly in developing and low-resource-setting countries.

From a scientific perspective, a public health scholar is established as a scientist who identifies, assesses, and produces relevant information to support health policies in the community. Zamrudiani, *et al.*, determined a relationship between the Composite Index of Anthropometric Failure and early childhood cognitive development (ECCD) in Indonesian children aged 36-59 months. In the 2018 Indonesian Basic Health Research, the authors later found a significant relationship between various anthropometric failures and ECCD as well as a combination of their relevance with other variables, such as access to drinking water and sanitation. The implication is that this study provided evidence that needs to be considered to prevent delays in the ECCD as it impacts people's health and life expectancy (pp. 235-243).

Although fertility rates have fallen in some developed countries, a demographic bonus will be experienced in developing and low-resource-setting countries. Supriatin, *et al.*, examined a correlation between the family planning decision-maker and modern contraceptive use among married/in-union women of reproductive age in Uzbekistan. By using the national secondary data analysis, the authors found that collaboration between partners and health workers could effectively raise the use of modern contraceptives. Nevertheless, further study still needs to be convinced that separating contraceptive methods into long and short-acting is the most relevant thing to do. Also, which women are considered instrumental in their decision is the most relevant factor in determining contraceptive choices (pp. 244-251).

Good knowledge also means a "color" in public health issues. Knowledge improvement plays a crucial role in behavioral changes at the primary level, targeting the general public, but it is also at the secondary and tertiary levels, such as knowledge in health workers about effective medication management that could minimize disability and cost-effectiveness. Ummee, *et al.*, statistically proved that educating caregivers of end-stage renal disease patients undergoing hemodialysis affected their knowledge of controlling excess fluid before and after education. Although further study is needed to ensure optimal outcomes for patients and their quality of life, this study illustrates the importance of education in improving healthcare workers' skills (pp. 258-264).

Simultaneously, the impact of social media on public health becomes an important concern if reminded that its largest users, such as college students, are at risk of experiencing social media disorder (SMD). Amelia, *et al.*, assessed social media use behavior and the prevalence of SMD and determined the relationship between the number of social media accounts and duration of social media use and SMD among the students. They found the must-have platforms: WhatsApp, YouTube, Line, and Instagram, which were widely used for interaction and entertainment, had a statistically significant relationship with the SMD. Although the duration of social media use contains no effect, the authors suggest further study to distinguish between the duration of social media use and the SMD when studying the impact of social media on mental health (pp. 265-270).

Besides, Khansa, *et al.*, evaluated solid medical waste management at the regional public hospitals in Bogor District, West Java Province, Indonesia. This case study design was conducted at four public hospitals according to the national standards, mainly for waste segregation and treatment. The study concludes that all the hospitals studied generate similar types of medical waste, e.g., infectious waste, pathological, sharp, pharmaceutical, and chemical waste; however, there is a hospital that delivers chemotherapeutic waste. Although the hospitals have already obtained an officially licensed government permit to manage such solid medical waste, complying with the standards, adequate standard operating procedures, such as providing the plastic bags with an appropriate color code and symbol as well as the medical waste trolly with sufficient amount, equipping emergency facilities in temporary storage, and providing comprehensive trainings to all the medical waste-related

workers about medical waste management are therefore essential for reduction activities implied to waste reduction in hospitals (pp. 217-225).

On the other hand, public health is said to be an art in the sense that it not only provides proof for evidence-based policymaking but also practically develops the tools. Yap, *et al.*, developed and validated a questionnaire based on the Person-Environment-Occupation (PEO) model and investigated the influence of personal, environmental, and occupational factors on the perception of seating ergonomics among drivers. The authors applied the PEO model to assess drivers' perceptions of seating ergonomics, which was developed to provide a framework for delivering services that embrace a client-centered approach. The tool then can be used as a reliable instrument to measure and determine the influence of each personal, environmental, and occupational factor on the drivers' perceptions of seating ergonomics, except for the psychometric properties that will be preferred to be overlooked further (pp. 226-234).

At the same point, Isworo, *et al.*, provided a tool to measure tuberculosis (TB) vulnerability in the community and guidance to prioritize and determine health system responses to TB based on different risk factors in communities. Identifying TB, particularly by finding active cases in vulnerable populations, has become a pivotal strategy arranged by developing countries, which include the Indonesian government.[3] The authors then employed a facet analysis of TB vulnerability components. Although the tool has not yet explored the validity of the instrument and the framework components in measuring the TB vulnerability level in the community, its application by big data, data linkage, and machine learning can potentially strengthen the identification and reduce TB (pp. 252-257).

Moreover, Sudiarno & Ma'arij applied a study at the warehouse in its daily activities and evaluated the abilities to maintain the flow and workers' safety based on the four pillars of resilience (Safety-II). This study used the Functional Resonance Analysis Method (FRAM) to discover higher variability in performance and safety occurring in activities that required a lot of individual or group effort and used a Resilience Analysis Grid (RAG) to assess the organization's potential for handling risks. Combining FRAM and RAG provides a new depth of perspective for safety analysis and addresses resilience factors in daily operations (pp. 271-278).

In the end, public health scholars are not only scientists with ability to discover science-based public health issues, but also as practice-based actors in the making; therefore, in this way, they navigate health in the community. Thus, it is not too much to consider that a public health scholar is well-fitted as a health leader rather than limiting them to either being a scientist or a single profession only.

Al Asyary*, Meita Veruswati, Putri Bungsu Machmud, Indri Hapsari Susilowati
The Editorial Board Members

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Correspondence: Al Asyary, Department of Environmental Health, Faculty of Public Health, Universitas Indonesia, Building C 2nd Floor, Kampus Baru UI Depok City, West Java 16424, Indonesia, Email: al.asyary@ui.ac.id, Phone: +62 813-4188-1814*

Khansa, *et al. Kesmas: Jurnal Kesehatan Masyarakat Nasional (National Public Health Journal)*. 2023; 18 (4): 217-225
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Kesmas: Jurnal Kesehatan Masyarakat Nasional (Kesmas: National Public Health Journal)

Evaluation of Solid Medical Waste Management in Bogor Regional Public Hospitals

Silvia Khansa[1], Agustin Kusumayati[1*], Dewi Susanna[1], Uli Tiarma Sinaga[2]

[1]Department of Environmental Health, Faculty of Public Health, Universitas Indonesia, Depok, Indonesia, [2]Environmental Office of Bogor District, Bogor, Indonesia

Abstract

Healthcare facilities generate medical waste. If not properly managed, medical waste may damage the environment and spread diseases. Many hospitals in Indonesia do not adhere to medical waste management regulations. This study aimed to evaluate the management of solid medical waste at four public hospitals in Bogor District, Indonesia. A case study design was used to obtain a comprehensive description of the solid medical waste management activities in the hospitals. Data were collected through direct observations, interviews, and document reviews. This study revealed that the medical waste generated in all hospitals was infectious, pathological, pharmaceutical, chemical, and cytotoxic, totaling approximately 4,000-12,000 kg. Hospitals A, B, C, and D fulfilled the Regulation of the Indonesian Ministry of Environment and Forestry No. P56 of 2015 criteria, achieving compliance rates of 77%, 83.78%, 83.3%, and 86.48%, respectively. However, several activities of the hospitals did not meet the standards for waste reduction, segregation, on-site transport, temporary storage, and human resource quality. It is important that hospitals establish comprehensive and compliant medical waste management systems.

Keywords: regional public hospital, solid medical waste, waste management

Introduction

Wastes are materials generated through human activities that cannot be recycled, discarded, or utilized.[1] Hospitals, as facilities where people seek healthcare services, typically generate both medical and non-medical waste. Medical waste is hazardous and toxic; therefore, it may adversely affect human health, cause accidents, and pollute the environment if incorrectly handled.[2] The World Health Organization (WHO) estimates that up to 15% of the waste generated by health facilities is medical waste.[4] Hospitals produce millions of tons of medical waste and utilize an estimated 16 billion needles annually.[3,4] However, the implementation of waste management is still poor, resulting in an enormous accumulation of medical waste that is not properly handled. Data from the WHO in 2015 stated that only half (58%) of health facility samples in 24 countries performed proper medical waste management.[4] Also, the WHO estimated that 23 million infectious diseases occur worldwide due to inadequate medical waste management.[5]

The handling of medical waste management in developing countries is quite worrisome. This is because health facilities have insufficient regulations, inadequate facilities, and challenges in monitoring waste management practices, such as segregation and disposal, within health facilities.[6] In addition, the reuse of needle waste from healthcare facilities in developing countries contributed to 33,800 new HIV cases, 1.7 million hepatitis B cases, and 315,000 hepatitis C cases.[7] As a developing country, Indonesia still has difficulties managing medical waste. In 2019, only 43% of hospitals complied with the regulations guiding the proper management of medical waste.[8] In the same year, the volume of medical waste produced by 2,820 hospitals and 9,884 primary health cares in Indonesia reached 290 tons/day.[9]

In contrast, the medical waste treatment capacity from hospital incinerators and licensed waste management services was only 220 tons/day, leaving 70 tons of waste neglected daily.[9] According to the Indonesian Ministry of Health data in 2022, approximately 84% of 402 hospitals did not provide medical waste management services for segregation and waste treatment.[10] The situation is exacerbated by the fact that there are only a few hospitals with licensed medical waste treatment faci-

Correspondence:* *Agustin Kusumayati, Department of Environmental Health, Faculty of Public Health, Universitas Indonesia, Building D 2nd Floor Kampus Baru UI Depok 16424, Indonesia, Email: agustin.kusumayati@ui.ac.id, Phone: +62 811-869-2434*

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lities. Moreover, among 2,880 hospitals in Indonesia, only 120 have incinerators, and only 5 have autoclaves.[10] Furthermore, there are only 165 licensed waste transporters and 20 licensed waste treatment service providers with uneven distribution.[2,10]

West Java, one of Indonesia's provinces, is the second-highest region with the most significant increase in medical waste generated during 2020-2021, up to 700 tons.[11] Furthermore, statistics from the Indonesian Ministry of Health data in 2022 show that 70.6% of hospitals in West Java Province do not provide medical waste management services, meaning that most hospitals in West Java Province do not perform waste segregation and treatment.[12] In Bogor, one of the widest districts in West Java Province, all the regional public hospitals do not perform waste management services based on the Indonesian Ministry of Health data in 2022.[12] Therefore, this study aimed to evaluate solid medical waste management at the public hospitals in Bogor District, West Java Province, Indonesia.

Method

This case study was conducted at four public hospitals (A, B, C, and D) in Bogor District, West Java, Indonesia. The selection of these hospitals was based on their classification as type-B facilities, characterized by complex facilities that produce substantial medical waste. These hospitals serve as local or regional referral hospitals. As per the data from the Indonesia Ministry of Health in 2022, they do not perform medical waste management according to the national waste segregation and treatment standard.[12]

This study was conducted from January to June 2023. Primary data were obtained through observations using checklist sheet requirements following the Regulation of the Indonesian Ministry of Environment and Forestry No. P56 of 2015. Additionally, interviews were conducted with the environmental health manager of each hospital to obtain information on medical waste characteristics and existing conditions for medical waste management. These include reduction activities, segregation, transportation, temporary storage, treatment, human resource quality, finance, and facilities and infrastructure. Secondary data were obtained through document review for policies, Standard Operational Procedures (SOP), permits, and reports related to medical waste management.

Data processing was carried out by summarizing and grouping data based on variables and then grading them according to the scope of the study. The data were analyzed by examining the characteristics of medical waste in each hospital, the availability of policies and SOP, facilities and infrastructure, finance and human resource quality, and the implementation of medical waste management between hospitals. Additionally, the percentage of compliance with medical waste management was determined from a checklist. The data are displayed in narrative and tabular forms.

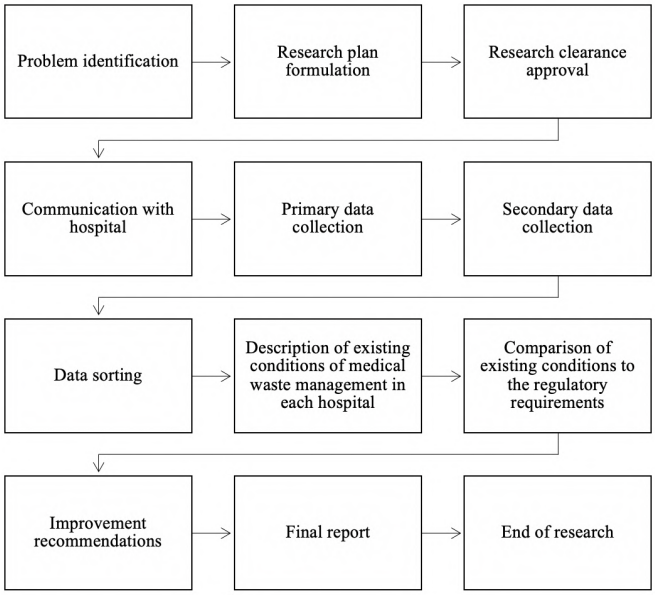

Figure 1. Study Framework

Results

Characteristics of Solid Medical Waste

Medical waste generated by four public hospitals in Bogor District included infectious materials, pathological waste, sharps, pharmaceuticals, and chemicals. Hospital B also produced cytotoxic waste from its chemotherapeutic activities. These wastes were generated from various facilities, including polyclinics, laboratories, pharmacies, radiology, hemodialysis, chemotherapy units, emergency rooms, intensive care units, inpatient and outpatient installations, forensic medical installations, neonatal-maternal installations, and surgical rooms. The data related to medical waste generation from January to April 2023 are compiled in Table 1.

Reduction Activities

In performing reduction activities, only Hospital A reused hemodialysis and laundry jerrycan waste as safety boxes; however, cleaning and disinfection were not conducted before their reuse. Furthermore, through collaboration with other parties, Hospital D recycled hemodialysis jerrycan, laundry jerrycan, and infusion plates not contaminated with patients' fluid or blood samples into non-food-grade products. Additionally, Hospital D provided cleaning, immersion with disinfectants, and chopping before the waste was delivered to an external party

Table 1. Medical Waste Generation in Four Public Hospitals in Bogor District

Month	Hospital A		Hospital B		Hospital C		Hospital D	
	Total (Kg)	Average (Kg/day)	Total (Kg)	Average (Kg/day)	Total (Kg)	Average (Kg/day)	Total (Kg)	Average (Kg/day)
January	4,665.23	150.49	8,947.01	288.61	4,333.24	139.78	1,2895.38	415.98
February	4,010.03	143.22	7,668.87	273.89	4,249.01	151.75	11,509.26	411.04
March	5,265.43	169.85	9,335.69	333.42	4,998.46	161.24	12,640.86	407.76
April	4,363.79	145.46	7,961.15	284.33	4,102.94	136.76	11,364.9	378.83

Table 2. Fulfillment Recapitulation of Medical Waste Management Implementation

Medical Waste Management Stream	Hospital A (%)	Hospital B (%)	Hospital C (%)	Hospital D (%)
Segregation	60	66.67	40	80
On-site transport	57.14	42.85	57.14	42.85
Temporary storage	81.25	100	100	100
Internal treatment	NA*	NA*	NA*	100
Off-site transport	100	100	100	100
External treatment	100	100	100	100
Total	77.78	83.78	83.33	86.48

Note: NA = not applicable because no activities were related to the stream.

for non-infectious waste recycling.

Furthermore, all hospitals implemented a first in, first out (FIFO) system to manage hazardous products, ensuring that they are equipped with stock cards and digital reports to record the inflow and outflow of products. Moreover, stock evaluations are conducted on a monthly basis. However, concerning the procurement of hazardous products, only Hospital C underwent the procurement process, facilitated by a single team operating within the pharmacy storage facility. In contrast, hazardous product procurement in the other three hospitals was carried out by separate teams, depending on the product type (medical and non-medical) and storage requirements. All hospitals also replaced hazardous products by converting mercury healthcare equipment into digital devices and digital radiology activities without red-ink immersion, fixers, or developers. Hospital B replaced the ethylene oxide sterilizer with plasma technology.

Medical Waste Management Stream

Medical waste management includes segregation, on-site transport, temporary storage, internal treatment, off-site transport, and external treatment. Table 2 presents the percentage of medical waste management implementation in each hospital, based on the observation checklist adhering to the Regulation of the Indonesian Ministry of Environment and Forestry No. P56 of 2015 criteria.

Waste Segregation

All hospitals sorted medical waste from their sources, carried out by waste officers involved in activities that generate it. Hospitals A and C provided medical waste containers, such as safety boxes for sharps waste and yellow plastic bags for all types besides sharps waste. In addition, Hospital A used hemodialysis or laundry jerrycan as safety boxes, although it was not equipped with medical waste labels.

Hospitals B and D provided containers, such as safety boxes, yellow plastic bags for infectious and pathological waste, brown plastic bags for pharmaceutical and chemical waste, and purple plastic bags for cytotoxic waste. Generally, plastic bags are placed in a secured bin and contain an information sticker describing the type and details of the medical waste. Hospitals C and D also established separate waste bins for recycling uncontaminated infusion plates.

Regarding the symbols and labels on plastic bags, Hospitals A and C did not provide yellow bags with infectious symbols and purple bags with cytotoxic symbols. In contrast, Hospital A provided plastic bags symbolizing infectious waste, and Hospital D provided a label indicating the type of medical waste attached to the bags.

On-site Transport

Regarding on-site transport of medical waste, only Hospital B handled medical and non-medical waste simultaneously using the same trolley without separate compartments. In contrast, other hospitals separately transported medical and non-medical waste using different transport schedules. Medical waste in Hospitals A, B, and C was transported every morning and afternoon. Hospital D transported medical waste at least once a day,

depending on the needs of each room and the amount of medical waste produced. Only Hospital B had a designated medical transportation route. However, certain waste officers at Hospital B transported medical waste using an elevator. In contrast, other hospitals transported medical waste using the same route as the patients and visitors. Additionally, all hospitals normally transport medical waste after transporting food to patients or not during visitor hours.

All hospitals used the same equipment for transport facilities: a wheeled trolley with a top cover, handgrip, and foot stomp to open the cover. However, none of the trolleys contained labels or symbols related to medical waste. Only Hospitals C and D cleaned their trolleys daily for trolley washing and disinfection activities. Hospitals A and B performed cleaning once a month and every two days for one week, depending on the physical condition of the trolley. In addition, the medical waste plastic bag ties in Hospitals A and C were all single ties, whereas some medical waste plastic bags in Hospitals B and D had bunny ear ties.

Temporary Storage

All hospitals had temporary medical waste storage licensed by the Bogor District Environmental Office. Hospital C had technical specifications that have become new licenses for hazardous waste storage. Hospital A had a 20'/6m container-shaped medical waste temporary storage as a form of cooperation with off-site transport services. However, the medical waste plastic bags were put on the floor because of the limited number of trolleys. In contrast, three other hospitals had separate buildings behind the hospital's main building in the form of partitioned/separated rooms for different types of medical waste and an adequate number of trolleys for medical waste plastic bags far from food supply and storage.

Hospitals A, B, C, and D had waterproof floors and flat surfaces. Water faucets, personal protective equipment (PPE), and medical waste containers were in or near the storage. Temporary storage contained hazardous symbols that officers could lock. The location was accessible to transport vehicles and waste trolleys, and there were no signs of animals or insects within the storage area. However, Hospital A lacked cleaning equipment and ventilation. In addition, Hospital A had an unsafe waste storage container cantilever that could cause accidents and falls, and the location was in an open space, which posed challenges to waste transportation when it rains.

Regarding the temporary storage cleaning schedule, Hospitals B and D cleaned their floors daily. Hospitals A and C cleaned the floor thrice a week after disposing of waste through a transporter to the external waste treatment plant. All hospitals temporarily stored the medical waste according to an off-site transport schedule. Pathological waste from Hospital D was stored in a sealed box with formalin and partially inside a refrigerator for up to three months. While, in Hospital B, pharmaceutical and cytotoxic waste was stored for a maximum of three months in a locked room within the pharmacy storage area. This precaution was taken to enhance the security of the drug waste before it was processed following the waste consignment flow mandated by the Bogor District Government.

Internal Treatment

All hospitals did not treat their medical waste independently. Hospitals A and C lacked waste treatment technologies. Hospital B had an incinerator, but it could not be used because it was still in the licensing process. Hospital D had a licensed incinerator; however, its activity was deactivated for maintenance in October 2022. While the incinerator was operational, Hospital D always performed gas emission and soil quality tests every six months, and the outcomes consistently demonstrated compliance with the specified limit for each tested parameter. Additionally, Hospital D collaborated with a licensed external party to manage the storage of residual ash resulting from the incineration process.

Off-site Transport

All hospitals collaborated with external waste transport services to deliver their medical waste from temporary storage in the hospital to an external hazardous waste treatment plant. Hospital A partnered with Company E; Hospitals B and D partnered with Company F; and Hospital C partnered with Company G. All these external parties had a license recorded in the Indonesian Ministry of Environment and Forestry and a four-wheel vehicle licensed from the Directorate General of Land Transportation. The waste transport schedules in Hospitals A, B, and C were held every Mondays, Wednesdays, and Fridays; whereas, Tuesdays, Thursdays, Saturdays, and Sundays were for Hospital D. However, Hospital B could transport their waste on Sunday if they arrange an appointment with the transporter.

The vehicle used was a four-wheeled box car with a separate room between the driver and the medical waste. The waste storage room was securely locked, had a company identity, an emergency number, and a hazardous waste symbol on the vehicle's body. Off-site transport begins with weighing and documenting the amount of medical waste. The next step was transporting medical waste inside the vehicle. Finally, both the hospital officer and transporter completed the waste consignment form before departing. Off-site transport was tracked and documented in a digital manifest (festronic) released by

the Indonesian Ministry of Environment and Forestry. In addition, the monthly balance sheet of medical waste generated and transported by the external transporter in each hospital showed no difference between the waste entering temporary storage and that being transported by the off-site transport service.

External Treatment

All hospitals collaborated with external hazardous waste treatment services through bipartite and tripartite agreements. Hospital A partnered with Company H, while Hospitals B, C, and D partnered with Company G. External companies obtained technical approval for hazardous waste treatment from the Indonesian Ministry of Environment and Forestry. They were also responsible for storing and treating the medical waste in the treatment facilities under national regulations, disposing of ash after treatment, documenting the related processes, and reporting activities using the same digital manifest as the off-site transport festronic.

Policy and Standard Operational Procedures

All the hospitals had specific policies related to hazardous waste management, including medical waste, in the form of directors' decisions (Table 3). Generally, the policies include the type and source of medical waste, medical waste management streams, and personal protection guarantees. In addition, all the hospitals had several SOPs related to medical waste management in their hospital area. Overall, these SOPs contained information about the definition of each SOP, purpose, related regulations, procedures, and units related to every SOP.

Human Resources Quality

Hospitals B and C trained all health personnel on medical waste management. The training, referred to as In-House Training, is conducted once a year with two speakers: one from the hospital's environmental health officer and the other is a certified person from an external party collaborating with the hospital. The In-house Training included hazardous waste management, proper securing of waste bags, and the management of hazardous material spills. Only new employees at Hospital A received education and training in medical waste management, unlike at Hospitals B and C. While, approximately 75% of Hospital D employees in medical waste management received basic training.

Finance

All hospitals planned separate budgets for medical waste each year. In general, hospital expenses for medical waste management included third-party services (off-site transportation and treatment), the supply of medical waste containers, PPE, hygiene procurement, and labels for waste bins. In addition, Hospital D incurred other expenses, such as maintenance costs for the incinerator. These expenses were determined and assigned appropriate account numbers as necessary.

Facilities and Infrastructure

Medical waste management in each hospital provided health personnel with complete PPE, including helmets, uniforms, head caps, aprons, goggles, rubber gloves, safety shoes, and masks, to process medical waste. However, some personnel did not use the PPE appropriately. Furthermore, waste transportation equipment and medical waste containers were provided by all hospitals, including wheel bins, medical waste plastic bags, and plastic bag waste bins. All hospitals had temporary medical waste storage facilities. Hospitals B and D obtained a new temporary storage license, Technical Specifications, for hazardous waste management. This was prompted by the limited space available for temporary storage in Hospital B. Notably, Hospital D had recently expanded its temporary storage capacity.

Table 3 Availability of Medical Waste Standard Operational Procedures

Standard Operational Procedure	Hospital A	Hospital B	Hospital C	Hospital D
Waste segregation	√	√	√	√
Insite transportations	√	√	√	√
Temporary storage	√	√	√	√
Off-site transportation	√	√	√	√
Medical waste treatment and disposal	√	√	√	√
COVID-19 waste management	√	√	√	√
Handling hazardous material	√	√	√	√
Main tasks, job description, and responsibilities of waste officer	-	√	-	-
Hazardous waste labelling	√	√	√	√
PPE utilization	√	√	√	√
Medical waste recycling management	-	-	-	√
Medical waste report	-	√	√	√

Notes: COVID-19: coronavirus disease 2019, PPE = Personal Protective Equipment

Discussion

Reduction of Solid Medical Waste

According to the Regulation of the Indonesian Ministry of Environment and Forestry No. P56 of 2015, the reduction of medical waste can be carried out by using the reuse, reduce, and recycle approach.[13] However, the process must be accurately executed through thorough cleaning and disinfection of waste packaging, infusion bottle waste, hemodialysis fluid packaging, and syringes before recycling and reusing.[13] Hospital A did not adhere to these standards before reusing hazardous waste.

Cleaning, decontamination, disinfection, and sterilization methods may be employed to reutilize medical waste, while some types of jerry cans can be reused after cleaning and disinfection.[14] Only Hospital C met the standard of centralized hazardous product procurement. Centralized hazardous procurement aims to reduce unnecessary purchasing, improve product inflow and outflow monitoring, and ensure compliance with waste reduction regulations.[16] All hospitals comply with the regulations by implementing the FIFO system and replacing hazardous goods with safer products.

Waste Segregation

All hospitals met the standards of the Regulation of the Indonesian Ministry of Environment and Forestry No. P56 of 2015,[13] for sorting medical waste as closely as possible to the source of the waste. However, Hospitals A and C did not meet the criteria because they did not supply brown plastic bags for pharmaceutical and chemical wastes, despite hospitals rarely producing these wastes. In addition, Hospitals B and C also did not meet the standards because there were no symbols for waste bags. Waste segregation must be carried out according to medical waste characteristics with proper color codes and labeled waste containers to ensure that waste separation can continue until the end of waste management.[15] Moreover, the goal of segregation is to identify different types of medical waste, mitigate the risk of personnel exposure to hazardous medical waste, and reduce costs associated with the treatment and disposal of medical waste.[17]

On-site Transport

All hospitals met the requirements of the Regulation of the Indonesian Ministry of Environment and Forestry No. P56 of 2015.[13] This involves regularly transporting waste from the source to temporary storage at least once a day or when the plastic waste bag is ¾ full.[13] Moreover, each hospital must be equipped with a wheeled trolley that adheres to established standards, ensuring ease of loading, unloading, and cleaning and possessing durable construction.[13] However, the trolleys in all hospitals lacked hazardous waste identity labels, hazardous waste symbols, and labels for the lid trolley positions. Furthermore, only Hospitals C and D met the daily cleaning and disinfection requirements for trolleys. The trolleys used must be disinfected using proper disinfectants, such as chlorine, carbolic acid, lysol, or similar substances.[18]

The goal of using separate routes for waste transport is to avoid aesthetic damage and transmission of nosocomial diseases in hospitals.[19] Hospitals A, C, and D did not meet the standard because no separate medical waste transport routes existed. Furthermore, on-site transport should be performed during quiet periods, and specific transportation hours should be established.[20] Regarding the shape of medical waste plastic bag ties, Hospitals B and D did not comply with the requirement, as their plastic waste exhibited bunny ear-tie shapes. According to the regulations, the tie shapes of bunny ears, tying with tape, and leaving the bag open are prohibited.[13] This prohibition is in place to prevent the risk of waste spillage during transportation to the waste treatment plant.[27]

Temporary Storage

All the hospitals complied with the regulations regarding the availability of permits and the construction of temporary storage.[13] Hospital C already has a new permit, per the new government regulation, where licenses for temporary hazardous waste storage are now issued in the form of technical specifications.[21] Under these regulations, building construction and container facilities are deemed suitable for temporary storage of hazardous waste.[22] Regarding the adequacy of facilities at temporary storage, only Hospitals B, C, and D met the regulatory requirements. Hospital A did not comply with certain requirements, such as the availability of cleaning equipment near storage and inadequate precautions against potential hazards. Hospitals are responsible for providing temporary storage with good lighting, PPE, cleaning equipment, waste containers near the storage site, appropriate symbols and signs of hazards, and limited access that can be locked.[23,24] Hospitals B and D were the only hospitals that met the standard of the temporary storage cleaning routine, as they cleaned these facilities daily.

Furthermore, Hospitals A, B, and C still did not meet the regulatory requirement regarding storage duration because the transportation schedule from Friday to Monday exceeded two days for storing infectious, pathological, and sharps waste. In addition, Hospital D did not comply with the provision for storing pathological waste for up to three months without a coolbox. The Regulation of the Indonesian Ministry of Environment and Forestry No. P56 of 2015 states that infectious, sharps, and pathological waste should be stored in temporary storage for a maximum of two days at >0°C or 90 days at <0°C. In contrast, chemical, cytotoxic, and pharmaceutical waste

can be stored for up to 90 days if it weighs >50 kg and up to 180 days if it weighs <50 kg.[13] The time limits for storing medical waste in temporary storage serve to minimize the growth of pathogens, decomposition, and odors.[23]

Internal and External Treatment

Hospital D complied with the regulations regarding waste treatment because it already had a permit from the Indonesian Ministry of Environment and Forestry to process medical waste using an incinerator. Incineration is the process of burning hazardous waste at high temperatures to eradicate toxic and hazardous substances using an incinerator.[25] The temperature range in an incinerator is around 1,600–2,500°F, and the process takes about 30 to 90 minutes. The burning process of an incinerator must eliminate at least 99.99% of the pollutants in the waste, and the residual ash from these activities is disposed of in sanitary landfills.[25]

All hospitals complied with the regulation,[13] by collaborating with licensed stakeholders, supported by written agreements. Furthermore, external waste treatment activities were guided by the same manifest as the off-site transport activities. Several factors must be considered when conducting waste treatment with external parties. The chosen external parties must have permission from the government, be able to manage medical waste treatment and disposal according to relevant regulations, and hold a consignment for the arrival of medical waste.[14]

Off-site Transport

Waste transporters are required to hold a permit for hazardous waste transport activities.[13] All hospitals complied with the standard because they collaborated with waste transport companies with government permits, including permits for hazardous waste delivery vehicles. In medical waste management, external transportation is usually outsourced to third parties.[26] Therefore, it is imperative to establish a written agreement outlining every operational detail; moreover, regular monitoring is essential to ensure that the activities align with the stipulated regulations.[26] Furthermore, the specifications of the medical waste transport vehicles and the manifests in the hospitals conformed to established standards.

Policy and Standard Operational Procedure

All hospitals had specific policies and SOPs concerning the management of solid medical waste. It is imperative to establish a comprehensive medical waste management policy for the sustained effectiveness of medical waste management.[26] This policy should align with national regulations and facilitate collaboration with stakeholders.[28] Furthermore, well-defined SOPs are essential to optimize the efficiency and accuracy of medical waste management activities.[29]

Human Resources Quality

According to the Regulation of the Indonesian Ministry of Environment and Forestry No. P56 of 2015, all personnels involved in hazardous waste management must have received proper training.[13] Hospitals A and D did not meet the standard because they have not adequately trained all human resources in medical waste management. The training seeks to enhance the understanding of health, safety, and environmental issues associated with medical waste. This will empower workers to conduct appropriate practices and understand their roles in sustainable medical waste management.[30]

Finance

All hospitals had annual budget plans for medical waste management. Budget planning is conducted following fund allocation from the government budget. Funds allocated for medical waste management are key to ensuring that medical waste management activities are carried out effectively and sustainably.[31] Medical waste management costs are separated into investment and operational costs.[24] The investment costs expended by these hospitals included PPE (uniforms, helmets, and safety shoes). Operational costs encompassed various items, including disposable PPE (head cap, mask, gloves, and apron), cleaning supplies, medical waste container procurement, equipment maintenance, and third-party vendors.

Facilities and Infrastructures

All hospitals complied with the regulation,[13] regarding the availability of PPE and the physical conditions of transport equipment. However, Hospitals A, B, and C did not meet the standards for medical waste containers or medical waste bag symbols. Furthermore, all hospitals had licensed separate buildings and containers for temporary medical waste storage. The old license for temporary storage has a five-year renewable term and can be extended.[29] However, there was an adjustment in the permit process according to the most recent laws, which is permanently valid unless temporary storage is changed. The most recent permits are in the form of technical specifications for storing hazardous waste.[32]

Conclusion

Based on the availability of solid medical waste management reporting activities, permits related to temporary storage for medical waste ownership, and collaboration with licensed external parties that officially have government permits to manage solid medical waste indicate that all hospitals adhere to the regulatory standards. The recommendations for all hospitals are providing ade-

quate SOP for reduction activities, providing plastic bags with appropriate color codes and symbols as well as an adequate number of medical waste trollies, equipping the emergency facilities with temporary storage, and providing comprehensive training on medical waste management to all medical waste personnel.

Abbreviations

WHO: World Health Organization; SOP: Standard Operational Procedure; FIFO: First In First Out; PPE: Personal Protection Equipment.

Ethics Approval and Consent to Participate

This study was approved by the Research and Community Engagement Ethical Committee of the Faculty of Public Health, University Indonesia, with number: Ket- 91/UN2.F10.D11/PPM.00.02/2023. Written informed consent was obtained from all participants.

Competing Interest

The authors declared no significant competing financial, professional, or personal interests that may affect the performance or presentation of the work described in this manuscript.

Availability of Data and Materials

All data and materials from this study can be given by the primary author.

Authors' Contribution

SK designed the study, developed the instrument, performed the data analysis and interpretation, and drafted the manuscript; AK, DS, and UTS reviewed the manuscript, advised on the data analysis and interpretation, and contributed to proofreading.

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Development and Validation of Perception of Seating Ergonomics Questionnaire: A Study on Klang Valley Drivers in Malaysia

Choy Min Yap, Hanif F M Rasdi*, Dzalani Harun, Wen Xin Lim

Occupational Therapy Program, Center for Rehabilitation & Special Needs Studies (iCaRehab), Faculty of Health Sciences, Universiti Kebangsaan Malaysia, Kuala Lumpur, Malaysia

Abstract

Driving is an instrumental activity of daily living that has become an essential mode of transportation. Good ergonomic practices are vital to ensure successful driving. This study aimed to develop and validate a questionnaire that could be used to determine how personal, environmental, and occupational factors influence drivers' perceptions of seating ergonomics. This cross-sectional study was conducted in June-July 2022 among 250 drivers in the Klang Valley, Malaysia, recruited via an online survey. The participants completed the questionnaire by assessing different constructs in the Person-Environment-Occupation model and perceptions of seating ergonomics. Exploratory factor analysis (EFA) was conducted, followed by a path analysis. Test-retest reliability was assessed in 30 participants. The final EFA generated a four-factor structure that accounted for 61.69% of the variance. The final version of the questionnaire contained 19 items. The Cronbach's alpha values for all the constructs were above 0.7, and all the intraclass correlation coefficients were above 0.8. Based on the path analysis results, personal and occupational factors emerged as significant predictors for drivers' perceptions of seating ergonomics. The developed questionnaire was valid and reliable.

Keywords: musculoskeletal disorders, occupational therapy, Person-Environment-Occupation model, psychometric properties, rehabilitation

Introduction

According to the International Ergonomics Association, the scientific discipline of ergonomics aims to develop the understanding of interactions among humans and other system elements.[1] An ergonomist applies theory, principles, data, and methods to design to optimize human behavior, well-being, and overall system performance.[1] The term "human factor" is often used interchangeably or as a unit with the term "ergonomics."[1] Ergonomics leads to safe and sustainable work systems by considering the interrelatedness of human, technical, and environmental components, as well as the potential effects of work system design changes on all parts of the system.[1]

Ergonomics is essential in reducing the risk of injury and increasing productivity.[1] Therefore, good ergonomic practices should be incorporated into daily activities, such as cooking, reading, and driving. As a developing country, Malaysia is experiencing significant population expansion, road length, and the number of registered vehicles.[2] According to the Census and Economic Information Center, 17,486,589 vehicles were registered in Malaysia in December 2020.[3] This was a rise compared to the 17,283,951 units identified in September 2020.[3] Driving has become an essential mode of transportation. As car ownership increases, drivers' seating ergonomics becomes increasingly necessary to ensure community safety and health.

Driving is an instrumental activity of daily living that requires complex cognitive processes and motor coordination.[4] Successful driving can positively influence one's health-related quality of life.[5] Good driving performance may rely on credible drivers, optimum vehicle conditions, and smart road design.[4] Driving posture is a critical factor impacting a driver's seating comfort.[5] As the science of ergonomics is essential to making road driving safe and comfortable, drivers should adopt a more active role in addressing the different ergonomics issues that may occur while driving.

Perception is defined as the distinctive way an individual or group views an occurrence, making it a potent driving force for action.[6] Although perception has been widely studied, capturing the concept meaningfully is problematic as it depends on self-reports of covert attri-

Correspondence: Hanif F M Rasdi, Occupational Therapy Program, Center for Rehabilitation & Special Needs (iCaRehab), Faculty of Health Sciences, Universiti Kebangsaan Malaysia, Raja Muda Abdul Aziz Street, 50300, Kuala Lumpur, Malaysia, E-mail: hanif_ot@ukm.edu.my, Phone: +60 392-897-374*

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butes. The most popular strategy for estimating perception is to use quantitative surveys, especially Likert-type scales.[6] A study by Yitayal, *et al.*, found that ergonomics awareness was a significant determinant of lower-back pain among drivers.[7] Moreover, AL-Dubai, *et al.*, found that lower-back pain was significantly associated with an awareness of ergonomics factors among taxi drivers in Malaysia (p-value<0.001).[8] Most participants (52.5%) stated they were unaware of good sitting posture and its importance.[8] In another study by Mohamad, *et al.*, 77% of survey subjects agreed that driving posture might influence discomfort while driving.[9] Furthermore, ergonomically designed drivers' car seats were crucial as they could enhance drivers' safety and comfort while driving and controlling the car.[9]

This study applied the Person-Environment-Occupation (PEO) model to assess drivers' perceptions of seating ergonomics. This was developed to provide a framework for delivering services that embrace a client-centered approach.[10] The model emphasizes occupational performance shaped by interactions between person, environment, and occupation.[10] A better fit of the three constructs indicates more meaningful participation. The outcome of the fit between the transaction of three components is defined by the quality of experience concerning individual levels of satisfaction and functioning.[10]

Hutchinson, *et al.,* conducted a qualitative study to understand the lived experiences of drivers with disabilities.[11] The PEO model was applied to develop and interpret the analysis, which had been extensively applied as an orientating framework when evaluating occupational performance issues and previously used in the transportation context.[11] The study suggested that the model was beneficial for conceptualizing how individuals interact with the environment.[11] The PEO model can be applied to identify occupational performance issues, strengths, and problems by, first, evaluating environmental conditions and, second, analyzing client performance components and occupational elements.[10] In this study, driving was regarded as the occupation, and the driver was the person. Driving occurred in a context that comprised physical, social, cultural, and socioeconomic factors.

Ergonomics was first introduced in Malaysia in 1992 when an ergonomics division was established within the National Institute of Occupational Health (NIOSH).[12] The Social Security Organization (SOCSO), a government agency under the Ministry of Human Resources, was established to administer and implement social security schemes under the Workers' Social Security Act 1969.[13] According to an annual SOCSO report, the total number of cases involving musculoskeletal problems recorded in 2015 was 1,123. This figure increased in the following four years (2016: 1,607 cases; 2017: 2,035 cases; 2018: 2,099 cases; and 2019: 2,352 cases).[13] A summary of the occupational accidents reported by the International Labour Organization, SOCSO, and the Department of Occupational Safety and Health revealed the general deficiency of the health and safety situation of workers worldwide.[14] The number of reported cases has been rising in recent years.[14] In general, little is known about ergonomics perception and practice among drivers in Malaysia.

Several studies have investigated how ergonomic practices affect the driving performance of professional drivers.[15] However, to date, a limited number of studies have focused on global perceptions of seating ergonomics among general drivers. Moreover, no study has applied the PEO model to analyze drivers' perceptions of seating ergonomics. Thus, this study aimed to develop and validate a questionnaire based on the PEO model and investigate how person, environment, and occupation factors influenced the perception of seating ergonomics among drivers in the Klang Valley, Malaysia. This study may improve the current driving rehabilitation practice in Malaysia and worldwide.

Method

This quantitative study, which used a cross-sectional design, was conducted in September 2021-July 2022 to, first, develop the questionnaire related to drivers' perceptions of seating ergonomics and, second, determine the influence of person, environment, and occupational factors on drivers' perceptions of ergonomics. This study was divided into two phases. The first focused on the questionnaire development, while the second focused on determining its reliability and validity and examining the constructs' relationships.

During the first phase, the Drivers' Perception of Seating Ergonomics Questionnaire was developed based on the practice guidelines recommended by Ikart.[16] Relevant literature on driving ergonomics and the PEO model was reviewed to construct the questionnaire items. Before developing the questionnaire, each construct being examined was defined to facilitate the item construction and content validation process.[17] The initial version of the questionnaire was distributed to six content experts with in-depth knowledge of this domain.[18]

Academic experts with a doctorate of philosophy in a field related to rehabilitation or ergonomics (n = 2); clinicians with at least five years of clinical experience in the physical rehabilitation field (n = 2); and professional drivers with at least two years of work experience (n = 2) were recruited via purposive sampling. After approaching the experts and obtaining their consent, a content validation form was distributed. Modifications were made based on their recommendations.

The modified version of the questionnaire was again subjected to the content experts' judgment to determine

its validity. As a result, the questionnaire showed excellent content validity. The item-level content validity indexes (I-CVIs) and modified kappa values of all 28 items were excellent, with all the values scoring above 0.80 for relevance, simplicity, and clarity.[17]

The questionnaire was then distributed to target-population judges (n = 10) as part of a feasibility test.[19] The inclusion criteria were as follows: (a) Malaysians living and working (if applicable) in the Klang Valley; (b) aged 18 years or above; (c) holding an active and valid license; (d) with a minimum of one year of driving experience and (e) had driven at least once a week in the past month. The face validation form was created using Google Forms and distributed to the target-population judges. A quantitative analysis of the percentage of agreement was conducted, along with qualitative analysis, to determine the clarity of wording, feasibility, readability, and questionnaire layout. After reviewing the feedback, minor changes were made. The finalized questionnaire was then administered to drivers in the Klang Valley.

The second phase was conducted among drivers in the Klang Valley in June-July 2022. The required sample size was calculated according to the recommendation given by Beavers, *et al.*,[20] for exploratory factor analysis (EFA) to feature at least 100 cases, and a subjects-to-variables (STV) ratio of no less than five was achieved.[20] The following inclusion criteria were applied in the study: (a) Malaysians living and working (if applicable) in the Klang Valley; (b) 18 years old or above; (c) holding an active and valid license; (d) having a minimum of one year of driving experience and (e) had driven at least once a week in the past one month. Individuals over 60 years and OKU card holders (a document for persons with disabilities) were excluded.

An informed consent form and a copy of the finalized questionnaire were converted into Google Forms, links for which were distributed publicly through online platforms. The survey invitation text included a brief explanation of the purpose. Eligible drivers could either ignore the invitation or self-decide to take the survey by clicking on the survey link in the text. The respondents had to read and agree to points on the consent form before starting the survey. A total of 263 responses were collected via convenience sampling. The demographic data of the respondents were screened. Thirteen responses were excluded for two reasons: five respondents were 60 years old or above, while eight had no valid driving license. After the screening, 250 respondents were recruited for the study.

In the second phase, participants were required to complete the self-administered questionnaire, which contained questions regarding their demographic data, driving profile, person constructs, environment construct, occupation construct, and perception of seating ergonomics construct. The questionnaire was divided into six sections. The first part of the questionnaire collected information on sociodemographic characteristics, such as each participant's age and sex. The second part included a driving profile (with features like years of driving and daily driving hours). The remaining four parts included items for different constructs, which were weighed by a 10-point Likert scale ranging from "Totally Disagree" to "Totally Agree." Seven items were used to measure each construct, and the participants were asked to indicate their level of agreement with each statement in the context of driving.

Descriptive statistics were conducted to analyze the participants' demographic information using IBM SPSS Statistics version 26 under license from the Universiti Kebangsaan Malaysia. Using the same software, EFA was performed using the principal component (PC) method and varimax rotation. The minimum factor loading criterion was 0.50.[21] The internal consistency of the questionnaire was tested using Cronbach's alpha. Subsequently, path analysis was conducted using IBM SPSS AMOS version 26 to investigate the relationships between the PEO factors and drivers' perceptions of seating ergonomics. The result obtained was compared with the bootstrapping results, in which the resampling number had been set to 1,000 times.[22] Finally, the test-retest reliability of the questionnaire was assessed after two weeks with a sample of 30 participants; to do this, a two-way mixed effects model, single measurement, and absolute agreement were used.[23]

Results

The sociodemographic characteristics of the participants are shown in Table 1. A sample numbering 250 drivers aged between 20 and 58 years participated in this study. The mean age was 27.29±7.67 years old. Most participants were female (72.0%) and Chinese (77.6%). The respondents had relatively high educational levels, with 83.6% completing undergraduate studies or above. The distribution of the drivers by location was as follows: 54.8% were from Selangor, 44.8% were from the Federal Territory of Kuala Lumpur, and 0.4% were from the Federal Territory of Putrajaya. Most (92.4%) had a class D license. The participants' mean years of driving were 7.75±6.79 years. Most drivers drove a five-seater vehicle (86.8%). The mean daily driving hours during weekdays were 2.09±2.21, while the mean daily driving hours during the weekend were 3.40±4.11.

The 28 original questionnaire items were submitted for EFA (n = 250) to assess the factor structure. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.916, and Bartlett's Test of sphericity was statistically significant (p-value<0.001). Both tests indicated that it was appropriate to conduct EFA. In addi-

Table 1. Descriptive Statistics of the Questionnaire (n = 250)

Variable	Category	n (%)	Mean ± Standard Deviation
Age (years)			27.29±7.67
Sex	Male	70 (28.0)	
	Female	180 (72.0)	
Ethnicity	Chinese	194 (77.6)	
	Malay	42 (16.8)	
	Indian	13 (5.2)	
	Sikh	1 (0.4)	
Highest educational level	Diploma and lower	41 (16.4)	
	Undergraduate	202 (80.8)	
	Postgraduate	7 (2.8)	
Living location	Selangor	137 (54.8)	
	Federal Territory of Kuala Lumpur	112 (44.8)	
	Federal Territory of Putrajaya	1 (0.4)	
Employment status	Employed	164 (65.6)	
	Currently a student	82 (32.8)	
	Currently unemployed	1 (0.4)	
	Had retired	3 (1.2)	
Type of driving license	D	231 (92.4)	
	DA	15 (6.0)	
	E	1 (0.4)	
	E2	3 (1.2)	
Number of years of driving			7.75±6.79
Daily driving hours during weekday			2.09±2.21
Daily driving hours during weekend			3.40±4.11
Type of vehicle transmission	Automatic	232 (92.8)	
	Manual	18 (7.2)	
Engine size of vehicle (in cc)	1,000 cc and below	52 (20.8)	
	1,001 cc to 1,200 cc	30 (12.0)	
	1,201 cc to 1,400 cc	48 (19.2)	
	1,401 cc to 1,600 cc	93 (37.2)	
	1,601 cc to 1,800 cc	11 (4.4)	
	1,801 cc to 2,000 cc	9 (3.6)	
	2,000 cc and above	7 (2.8)	
Number of seats in the vehicle	2 seats	10 (4.0)	
	4 seats	1 (0.4)	
	5 seats	217 (86.8)	
	7 seats	21 (8.4)	
	7+1 seats	1 (0.4)	
Body part that feels pain during driving	Neck	95 (38.0)	
	Shoulder	72 (30.0)	
	Upper back	34 (13.6)	
	Upper arm	13 (5.2)	
	Elbow	8 (3.2)	
	Wrist	14 (5.6)	
	Finger	9 (3.6)	
	Lower back	54 (21.6)	
	Hips	45 (18.0)	
	Thigh	11 (4.4)	
	Knees	20 (8.0)	
	Calf	23 (9.2)	
	Ankle	20 (8.0)	
	Foot	22 (8.8)	

tion, five factors had Eigen-values >1, indicating that the factor solution derived from this analysis produced five factors for the questionnaire.

In this initial EFA, an item was loaded in a factor alone. It was thus excluded, and the EFA was repeated with the remaining 27 items. The factor solution derived from the second analysis produced four factors for the questionnaire. An item with a commonality below 0.4 was excluded. To assist the factor interpretation and naming, four items loaded onto a factor other than its underlying factor were excluded. Lastly, three items that failed to load significantly on any dimension were removed.

The final analysis results produced four factors for the questionnaire. The Person, Environment, Occupation, and Perception of Seating Ergonomics constructs were

the four factors determined by the EFA. The KMO measure of sampling adequacy was 0.905, and Bartlett's Test was significant (p-value<0.001). All the commonalities were above 0.4. These factors could explain 61.69% of the total scale variance. Therefore, the construct validity of the questionnaire was established. The final version of the Drivers' Perception of Seating Ergonomics Questionnaire consisted of 19 items. The commonalities and factor loadings are presented in Table 2.

The Cronbach's alpha coefficients were computed to assess the internal consistency of the final version of the questionnaire. The Drivers' Perception of Seating Ergonomics Questionnaire had an overall Cronbach's alpha of 0.9. The Cronbach's alpha values for the Person, Environment, Occupation, and Perception of Seating Ergonomics constructs were 0.817, 0.704, 0.879, and 0.811, respectively. All these values were above the acceptance value of 0.7. For test-retest reliability, the differences between the total scores for both measurements for each construct were plotted against the average score of the two measures, with an upper and lower limit of agreement. An exemplary Bland and Altman plot was obtained for the Occupation Construct, as shown in Figure 1. For a 95% confidence interval, the intraclass correlation coefficients (ICC) for the Person, Environment, Occupation, and Perception of Seating Ergonomics constructs were 0.848, 0.893, 0.834, and 0.874, respectively. All four constructs displayed good reliability, as all

Table 2. The Results of Exploratory Factor Analysis and Reliability Testing

Factor	Item	Communality	Factor Loading	Cronbach's alpha	ICC	SEM
Factor 1: Person construct	P1	0.632	0.717	0.817	0.848	0.539
	P4	0.606	0.612			
	P6	0.729	0.783			
	P7	0.644	0.696			
Factor 2: Environment construct	E2	0.503	0.573	0.704	0.893	0.664
	E3	0.493	0.658			
	E4	0.737	0.802			
	E5	0.561	0.633			
Factor 3: Occupation construct	O1	0.678	0.534	0.879	0.834	0.930
	O3	0.683	0.726			
	O4	0.722	0.784			
	O5	0.762	0.827			
	O6	0.616	0.684			
Factor 4: Perception of seating ergonomics construct	SE1	0.518	0.599	0.811	0.874	0.957
	SE2	0.623	0.756			
	SE3	0.572	0.664			
	SE4	0.539	0.719			
	SE6	0.527	0.592			
	SE7	0.577	0.604			

Notes: ICC = Intraclass Correlation Coefficient, SEM = Standard Error Measurement

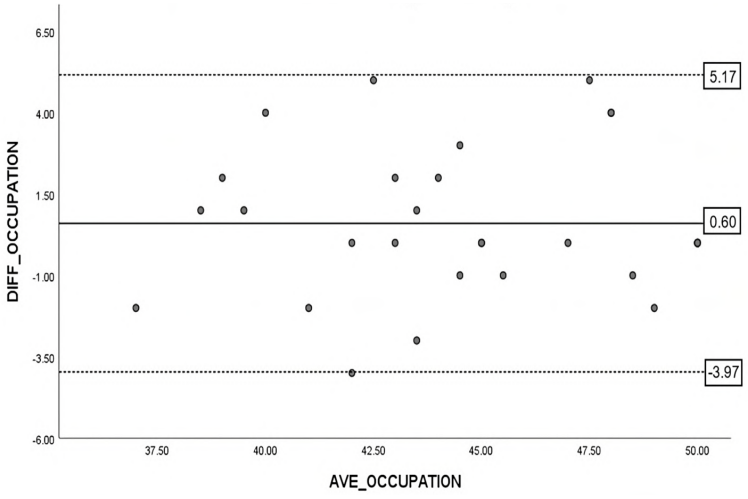


Figure 1. Bland and Altman Plot for Occupation Construct

the ICC values were above 0.75. The standard error of measurement (SEM) for the four constructs ranged from 0.54 to 0.96, with the Person construct having the SEM lowest value. The reliability testing results are shown in Table 2.

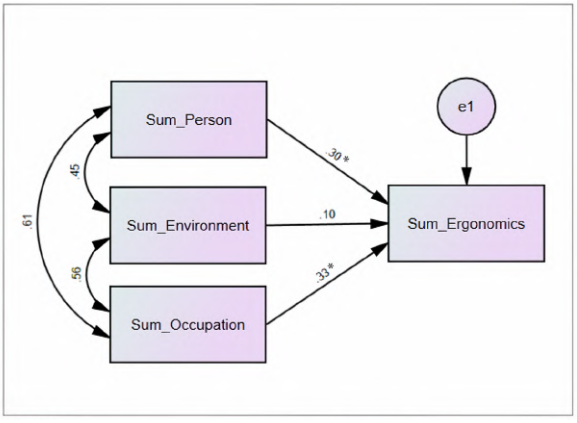
A path analysis was conducted to examine the association between the Person, Environment, Occupation, and Perception of Seating Ergonomics constructs. The first three were used as observed indicators of a latent variable: the perception of seating ergonomics. The path model is shown in Figure 2, while the bootstrapping results are reported in Table 3, with the Person and Occupation constructs emerging as significant predictors. According to the results, the Occupation construct (Sum_Occupation) had the most excellent significant relationship with drivers' perceptions of seating ergonomics ($\beta = 0.333$, p-value<0.05), followed by the Person construct (Sum_Person) ($\beta = 0.298$, p-value<0.05). On the other hand, the Environment construct (Sum_Environment) did not have a significant relationship with the drivers' perceptions of seating ergonomics ($\beta = 0.099$, p-value = 0.118, p-value>0.05).

Discussion

This study described the development and validation of the Drivers' Perception of Seating Ergonomics Questionnaire. The finalized questionnaire contained 19 items. This is the first questionnaire to apply the PEO model to explore predictors of drivers' perceptions of seating ergonomics in the development process. The PEO model has previously been used when developing instruments to examine the dynamic relationships between person, environment, and occupation in different contexts,[24] thus supporting the appropriateness of using the model as the theoretical foundation of the questionnaire development process in this study. This study examined the relationships between drivers, driving activities, environments, and drivers' perceptions of seating ergonomics. The proposed model incorporated the finalized items in the PEO constructs as direct predictors of drivers' perceptions of seating ergonomics. The psychometric properties within the questionnaire were examined using a sample of 250 Malaysian drivers in the Klang Valley.

The initial version of the questionnaire consisted of 28 items. However, modifications would be needed for new instruments.[17] Content validity is essential for researchers to realize whether the instruments they use are appropriate for the constructs, population, and sociocultural background of their particular studies.[17] Face validity is used as a subsidiary form of validity to support content validity.[17] It concerns item judgments after an instrument has been constructed. Hence, the questionnaire's validity was first confirmed using the content and face validity approaches. After conducting the initial EFA, the questionnaire items were found to be categorized into five factors. The factor analysis and item deletion procedures were then performed based on the recommendations and guidelines from previous studies.[25] During factor analysis, nine items from the initial questionnaire that had been content-validated were excluded. The EFA revealed that three items were deemed useless for measuring the specific constructs due to their low factor loading.[22] Based on the final EFA results, the components were named based on the PEO model. The first three constructs in the questionnaire referred to a range of personal, environmental, and occupational factors in the context of driving. Through EFA, the questionnaire's construct validity was established.

The reliability of the Drivers' Perception of Seating Ergonomics Questionnaire was confirmed by examining its internal consistency and test-retest reliability. The internal consistency among the 19 items for the whole questionnaire was 0.9, while Cronbach's alpha values for



*p-value <0.05

Figure 2. The Proposed Model for Path Analysis

Table 3. Bootstrapping Results of Path Analysis

Hypothesis	Estimate	Standard Error	Lower Bound	Upper Bound	p-value	Result
Sum_Ergonomics <--- Sum_Person	0.298	0.076	0.167	0.421	0.003	Significant
Sum_Ergonomics <--- Sum_Environment	0.099	0.068	-0.007	0.211	0.118	Non-significant
Sum_Ergonomics <--- Sum_Occupation	0.333	0.083	0.207	0.475	0.001	Significant

the four constructs ranged from 0.704 to 0.879; thus, all were within an acceptable range.[26] The questionnaire had good test-retest reliability as all four constructs had ICC values over 0.75.[27] Some outliers ranging from one to three were detected in the Bland and Altman plots for the four constructs. After investigation, the outliers were found to have arisen from data collected from Chinese participants. Therefore, the presence of these outliers may have been due to the differences when interpreting items in Malay after two weeks. Previous studies have identified how Malaysian Chinese tend to use Mandarin as their primary language in their daily lives.[28]

From the path analysis, the Occupation construct emerged as the most significant predictor of the perceptions of seating ergonomics. In this questionnaire, the Occupation construct consisted of items concerned with drivers' self-perceptions of driving-related occupation demands, organization, time, change, and routines. The findings suggested that such occupational factors significantly influenced drivers' perceptions of seating ergonomics. First, it is essential to note that according to the International Ergonomics Association definition of ergonomics,[1] cognitive ergonomics, which aims to support human well-being when executing tasks, studies human cognitive capacities (including memory, attention, and problem-solving) and performance outcomes (including the time taken when performing a task).[29] Therefore, the occupational factors included in the finalized version of the questionnaire developed in this study aligned with the focus on cognitive ergonomics. Furthermore, a previous study suggested that human error while driving could be understood based on individual differences in abilities to process information.[30] These findings supported the view that occupational factors concerned with human cognitive capacities and performance outcomes could be vital in influencing drivers' perceptions of seating ergonomics.

Besides the Occupational construct, the Person construct had a significant relationship with drivers' perceptions of seating ergonomics. The findings indicated that personal factors, including drivers' perceptions of their role, self-conceptualization, health, physical performance, and sensory capabilities, significantly influenced their perceptions of seating ergonomics. Deng, *et al.*,[31] supported these results, stating that visual abilities are essential for driving, especially driving safely. A similar result was observed in a study by Karali, *et al.*,[32] mentioning that a decline in physical capabilities could affect those driving a vehicle. Besides the need for drivers to have sufficient ability, Xu, *et al.*[33] stated that the factors of motivation, beliefs, and personal values were also important for driving safely as they could determine one's driving habits. A previous study further verified these notions, stating that individual perceived control to perform driving was significantly related to driving status.[34] These findings justified the results from the present study, which also revealed that personal factors had a significant relationship with drivers' perceptions of seating ergonomics.

In this study, the Environment construct was an insignificant predictor of the perception of seating ergonomics. This might have been due to personal and occupational factors having a more powerful influence on perceptions of seating ergonomics, which subsequently overshadowed the impact of environmental factors on drivers' perceptions while driving. This explanation could be supported by the argument of Hughes, *et al.*,[35] claiming that current road safety strategies could not cope with the impact of societal issues on road safety. However, the relationship between environmental factors and drivers' perceptions of seating ergonomics must be interpreted with caution as the findings of the present study contrasted with those of previous studies, which revealed that environmental factors, including weather conditions, were related to a driver's health, mental state, and driving performance.[36]

One strength of the current study was the sample size recruited. This was considerable, ensuring the adequacy of sampling for conducting factor analysis. However, this study had several limitations to consider when interpreting the results. First, convenience sampling was used to recruit drivers in the Klang Valley. Although the online survey permitted access to a larger respondent population, the disadvantage of conducting an online survey through convenience sampling was the risk of self-selection bias, as all the individuals were fully allowed to decide whether to participate.[37]

Furthermore, there was limited literature on developing an instrument based on the PEO model. Thus, it is recommended that the psychometric properties of the Drivers' Perception of Seating Ergonomics Questionnaire should be investigated further via confirmatory factor analysis. Additionally, the low percentage of males (28%) might limit the generalization of the results to male drivers.[5] Furthermore, the large proportion of Chinese respondents (77.6%) might affect the applicability of the findings in Malaysia's multi-ethnic population. Last, the cross-sectional design did not permit investigation of the eventual causal relationship between the three constructs and the drivers' perceptions of seating ergonomics. Although drivers' perceptions of seating ergonomics were explored using the newly developed questionnaire, the results were not quantified or interpreted by cut-off scores. Hence, further study is recommended to determine the questionnaire cut-off scores.

Conclusion

The questionnaire developed and validated in this

study could be used as a reliable instrument to measure and determine how personal, environmental, and occupational factors influence drivers' perceptions of seating ergonomics, which can, in turn, influence their ergonomic practices while driving. However, further study is recommended to examine the questionnaire's psychometric properties. As ergonomic driving posture is especially essential for drivers, future investigations may build upon this study by utilizing the questionnaire to guide investigations or interventions in study and clinical settings.

Abbreviations

PEO: Person-Environment-Occupation; NIOSH: National Institute of Occupational Health; SOCSO: Social Security Organization; EFA: Exploratory Factor Analysis; KMO: Kaiser-Meyer-Olkin measure; ICC: Intraclass Correlation Coefficients; SEM: Standard error of Measurement.

Ethics Approval and Consent to Participate

This study received ethical approval from the Research Ethics Committee of Universiti Kebangsaan Malaysia (Reference number: UKM PPI/111/8/JEP-2021-909). Before filling in the questionnaire, respondents must read and agree to the consent form to participate in this study.

Competing Interest

The authors declare no significant competing financial, professional, or personal interests might have affected the performance or presentation of the work described in this manuscript.

Availability of Data and Materials

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Authors' Contribution

HFR, DH, and YCM contributed to the design and implementation of the research and the analysis of the results. YCM and HFR verified the analytical methods, while DH and HFR supervised the findings of this work. HFR, DH, YCM, and LWX were responsible for the preparation of the manuscript, as well as the accuracy of all content in the proof, including the co-authors, addresses, and affiliations. All the authors discussed the results and contributed to the final manuscript.

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Composite Index of Anthropometric Failure and Early Childhood Cognitive Development Based on the 2018 Indonesian Basic Health Research Data

Safira Zamrudiani[1*], Abdul Wahab[1], Rosalia Kurniawati Harisaputra[2]

[1]Department of Biostatistics, Epidemiology, and Population Health, Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada, Sleman, Indonesia, [2]Center for Reproductive Health, Universitas Gadjah Mada, Sleman, Indonesia

Abstract

Delays in early childhood cognitive development may have profound long-term implications on health and life expectancy. Optimal nutrition supports early life development, including a child's cognitive development. This study aimed to determine the association between the Composite Index of Anthropometric Failure and early childhood cognitive development among children aged 36-59 months in Indonesia. This cross-sectional study utilized data from the 2018 Indonesian Basic Health Research that involved 18,027 participants aged 36-59 months. This study outcome demonstrated that children who were stunted-underweight were potentially susceptible to delayed cognitive development compared to those with normal nutritional status (aOR = 1.30; 95% CI = 1.12–1.51) after controlling for child's age, sex, vitamin A supplementation, antenatal care visits, gestational age, access to drinking water and sanitation (combined risk), maternal's education and mental health (combined risk), maternal's occupation and number of household members (combined risk). In summary, malnourished children are vulnerable to impaired physical growth and potential delays in early cognitive development.

Keywords: cognitive development, stunted, underweight, wasted

Introduction

Early childhood is a period when children acquire fundamental skills for development, education, social welfare, and healthy economic productivity that could determine their future.[1,2] Loss of optimal development is often caused by nutritional and environmental factors linked to growth and poverty.[3] Children from families of lower socioeconomic backgrounds generally experience a delay in cognitive function, characterized by a lag in expressive and receptive language, literacy, numeracy, and independence.[3,4]

Sustainable Development Goals (SDGs) indicator 4.2 focuses on age-appropriate developments in the health, learning, and psychosocial well-being of children between 24 and 59 months, measured based on their sex (4.2.1) and preschool learning participation rate (4.2.2).[5] Globally, approximately 200 million children under the age of five suffer from stunted, wasted, or both, and at least 340 million experience hidden hunger due to vitamin and mineral deficiencies.[6] In Indonesia, the prevalence of optimal cognitive development among children aged 36-59 months in the literacy-numeration and learning domains was 64.6% and 95.2%, respectively, in 2018.[7] The statistics reflected a lack of effort in ensuring optimal cognitive development among these children in Indonesia, particularly in the literacy-numeration domain.

Evolving literacy and numeracy capabilities are crucial components of communication.[8] Each individual engages in social practices daily, using literacy as a tool that encompasses knowledge and skills for efficient communication and idea representation.[9] Knowledge of numbers and quantities in numeracy skills has been shown to set the fundamentals for superior math skills and complex problem-solving abilities up to six years later among 54-month-olds.[10]

A previous study reported that children with double failure (stunted-underweight) and triple failure (stunted-underweight-wasted) nutritional status significantly delayed their under-five child development (β = -0.15; 95% CI = -0.20 to -0.10) after controlling for variables such as child's age, sex, maternal's age, parental education, stimulation, participation in early childhood education, number of household members, household wealth, and

Correspondence:* *Safira Zamrudiani, Department of Biostatistics, Epidemiology, and Population Health, Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada, Special Region of Yogyakarta 55281, Indonesia, E-mail: szamrudiani@gmail.com, Phone: +62 812-7416-2347*

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rural residence.[11] While, a longitudinal study by the Institute of Nutrition of Central America and Panama demonstrated a significant relationship between inadequate nutrition in infancy and deficits in cognitive development and academic achievement during childhood and adolescence/young adulthood.[12]

The Early Childhood Development Index (ECDI) has been implemented in more than 70 countries via Multiple Indicator Cluster Surveys as one of the first initiatives to gather population-level data on early childhood development in the last two decades.[13] The ECDI was also conducted in Indonesia as part of the 2018 Indonesian Basic Health Research (IBHR). This study utilized the Composite Index of Anthropometric Failure (CIAF) to investigate the association between nutritional status and undernutrition with early childhood cognitive development (ECCD) in Indonesia. This study aimed to determine the association between CIAF and ECCD in Indonesian children aged 36-59 months and to identify the presence of confounding variables and modifying effects of the association between CIAF and ECCD.

Method

The data utilized in this study were sourced from the 2018 IBHR. It is a national survey performed in Indonesia every five to six years using a cross-sectional study design. This survey offers insights into various health parameters in the country. A multistage sampling technique was adopted for random selection, representing the entire population in the country, provinces, and district/city areas.

Of 24,926 children aged 36-59 months, 18,072 (72.5%) were eligible for this study. The inclusion criteria were children aged 36-59 months who were successfully interviewed, had records of growth and development monitoring (measured height and weight), and had a record of antenatal care (ANC) visits handled by health providers. The exclusion criteria were children with missing data on variables and at risk of disability.

The ECDI comprises four domains: learning, physical, social, emotional, and literacy-numeracy. The literacy-numeracy and learning domains in IBHR consisted of six criteria to identify children with delayed cognitive development.[14,15] The six items were K50: Can say their name without assistance; K51: Can read at least four simple and popular words; K52: Knows names and recognizes the symbols of all numbers from 1 to 10; K55: Can name at least ten letters of the alphabet, K56: Follows simple directions on how to do something correctly, K57: When given something to do, they can do it independently. All items were reported in a simple binary (yes/no) response. This method was adapted from a previous study to determine cognitive delay, defined by the inability to perform all six tasks.[14]

The field assessment teams of the IBHR calibrated the equipment every morning before data collection.[16] The children's weight was measured using a digital weighing scale, and their height was measured using an adjustable and multifunction measuring tool. The height of children older than 24 months was measured while standing. Children's anthropometric failures are determined by stunting, wasting, and underweight.[17]

The Indonesian Ministry of Health Regulation No. 2 of 2020 concerning child anthropometry standards was used in this study to convert the height and weight measurements into age and sex-specific z-scores.[18] The CIAF formula of multiple and concurrent failures was used to determine the three binary categorizations of anthropometric failures employed in previous study.[11] Subsequently, the results were divided into seven groups, as detailed in Table 1.

There were other independent variables used in this study: vitamin A supplementation, ANC visits, mother's education, occupation, and mental health, and access to drinking water and sanitation. The Indonesian Minister of Health Regulation No. 43 of 2016 stated that registered midwives, nurses, doctors, and pediatricians can prescribe vitamin A supplementation.[19] Vitamin A capsules were provided twice annually in public and private health facilities and it had been done in the last 12 months.

In this study, the data on vitamin A supplementation were recorded based on the information provided by the mother or caregiver of the child, with a recall interval of

Table 1. The Composite Index of Anthropometric Failure Categories

Category	WAZ (z-score < -2 SD)	HAZ (z-score < -2 SD)	WHZ (z-score < -2 SD)
No failure	-	-	-
Underweight	✓	-	-
Wasted	-	-	✓
Stunted	-	✓	-
Underweight and wasted	✓	-	✓
Stunted and underweight	✓	✓	-
Stunted, wasted, and underweight	✓	✓	✓

Notes: WAZ = Weight for Age, HAZ = Height for Age, WHZ = Weight for Height, SD = Standard Deviation

12 months prior to the interview. While, the data on ANC visits referred to the frequency of prenatal examinations for mothers in each trimester by health providers. The Indonesian Minister of Health Regulation No. 97 of 2014 was implemented nationwide when the 2018 IBHR was conducted; thus, the frequency of ANC visits was at least four times during pregnancy.[20]

Mother's education was divided into three categories: low (never attended school, did not complete primary school, completed primary school, and completed junior high school); middle (completed high school); and high (graduated from college). This study adapted the mother's occupation categories from a previous study: civil servant/private employer (civil servants, Indonesia National Armed Forces, Indonesia National Police, state-owned or regionally owned enterprises); entrepreneur (traders of agricultural, plantation, or forestry products); laborer (individuals whose profession involves processing the work of others and do not earn a stable or income); and others (individuals whose profession does not belong to previous categories).[21]

Maternal's mental health referred to mothers with common mental disorder (CMD). The Self-Reporting Questionnaire (SRQ-20) with CMD psychometric classification developed by the World Health Organization was used as a diagnostic and screening tool comprising 20 items (yes/no) to determine the risk of mental disorders among participants. The most common mother's mental health disorders identified as risks in the SRQ-20 were depression, anxiety, and stress.[22] The cutoff score in this study was "yes" answers for at least eight items overall, and the reference category was non-CMD mothers.

The primary source of drinking water referred to the supply through pipes, public taps or standpipes, tube wells or boreholes, protected wells, protected springs, or rainfall shields. Anything beyond these categories was considered "unimproved" for access to drinking water variable. While, access to sanitation referred to facilities that were not shared, complete with piped sewage system or septic tank or pit (latrine), ventilated pit latrines, pit latrines with slabs, or composting toilets. Anything in these categories was considered "unimproved."

The first phase involved the estimation of prevalence for all variables among children aged 36 to 59 months using simple descriptive analyses. Second, the bivariable analyses were performed to identify the odds ratio (OR) and p-value for each independent variable, followed by the Chi-square test to determine the relationship with ECCD. The third analysis stage assessed the variables' interaction between CIAF and ECCD. Finally, multivariate analyses with logistic regression were conducted to estimate the confounding variables, adjusted odds ratio (AOR), and the relationship between CIAF and ECCD by considering other independent variables. Statistical analyses are estimated with a 95% confidence interval (CI) and using the complex samples facility to account for the within-country sampling clusters and the clustering of observations by country.

Result

Table 2 presents the overall descriptive data for 18,072 children in Indonesia. There was a high prevalence of delayed ECCD (61.21%). More than half of the study sample were between 36 and 47 months (52.49%), were boys (51.21%), and were supplemented with vitamin A twice annually (58.06%). Most participants had a record of more than four ANC visits (91.57%), and 64.2% had no failure in CIAF. Furthermore, 71.56% recorded a gestational age of ≥37 weeks, and 54.40% were middle-aged mothers (25 to 34 years). In addition, 54.4% of mothers had low education, 55.49% were un-

Table 2. Participants Characteristics (n = 18,072)

Variable	Category	n	%
Early childhood cognitive development	Normal	7,009	38.79
	Delayed	11,063	61.21
Composite index of anthropometric failure	No Failure	11,603	64.2
	Underweight	339	1.88
	Wasted	493	2.73
	Stunted	2,776	15.36
	Underweight and wasted	574	3.18
	Stunted and underweight	1,893	10.47
	Stunted, wasted, and underweight	394	2.18
Child's age	36–47 months	9,486	52.49
	48–59 months	8,586	47.51
Sex	Male	9,254	51.21
	Female	8,818	48.79
Vitamin A supplementation	Twice	10,494	58.06
	Once	5,125	28.36
	Never	2,454	13.58
Antenatal care visits	<4 sessions	1,523	8.43
	≥4 sessions	16,549	91.57
Gestational age	<37 weeks	5,140	28.44
	≥37 weeks	12,932	71.56
Maternal's age	Young (15–24 years)	2,582	14.29
	Middle (25–34 years)	9,831	54.40
	Late (≥35 years)	5,659	31.31
Maternal's education	Low	9,738	53.89
	Middle	6,090	33.70
	High	2,244	12.42
Maternal's occupation	Civil servant/private employer	4,259	23.57
	Entrepreneur	1,477	8.17
	Laborer	930	5.15
	Other	1,378	7.62
	Unemployed	10,028	55.49
Maternal's mental health	CMD (score ≥8)	859	4.75
	Non-CMD (score <8)	17,213	95.25
Access to drinking water and sanitation	Improved	3,255	18.01
	Poor	14,817	81.99
Type of residence	Urban	10,318	57.09
	Rural	7,754	42.91
Number of household members	<5 people	10,656	58.96
	≥5 people	7,416	41.04

Note: CMD = Common Mental Disorders

employed, and 95.25% were non-CMD. Most respondents had poor access to drinking water and sanitation (81.99%), lived in urban areas (57.09%), and had <5 members in a household (58.96%).

Figure 1 demonstrates the distribution of respondents, where the categories for children's age and sex variables were almost comparable. Children who experienced delayed cognitive development were then classified based on genetic factors (age and sex), which are highly prevalent in boys between 36 and 47 months. Figure 2 illustrates that stunted nutritional status was more prevalent than other anthropometric failures, followed by stunted-underweight and stunted-wasted-underweight. This trend indicated chronic-acute nutritional problems within the study population.

Table 3 demonstrates that children with stunted and wasted nutritional status had a 1.35 times higher risk (95% CI = 1.16–1.56) of experiencing delayed cognitive development, while stunted children faced a 1.17 times

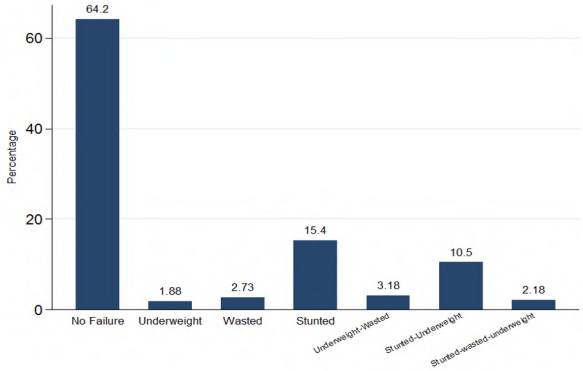
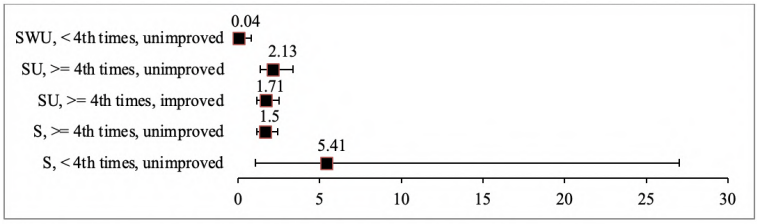


Figure 1. Prevalence of Children's Nutritional Status in Indonesia Based on Composite Index Anthropometric Failure in 2018

Table 3. Bivariate Analysis between Composite Index Anthropometric Failure and Other Independent Variables with Early Childhood Cognitive Development in Indonesia (n = 18,072)

Variable	Category	Early Childhood Cognitive Development				OR	95% CI
		Delayed		Normal			
		n	%	n	%		
Composite Index of Anthropometric Failure	No failure	6,972	60.1	4,630	39.9	1	1
	Underweight	218	64.2	121	35.8	1.19	0.89–1.60
	Wasted	245	49.8	248	50.2	0.66**	0.50–0.87
	Stunted	1,770	63.8	1,006	36.2	1.17*	1.03–1.32
	Underweight and wasted	333	57.9	242	42.1	0.91	0.72–1.16
	Stunted and underweight	1,267	67.0	626	33.1	1.35***	1.16–1.56
	Stunted, wasted, and underweight	257	65.3	137	34.7	1.25	0.92–1.69
Age	36–47 months	6,447	68.0	3,039	32.0	1.82***	1.67–2.00
	48–59 months	4,616	53.8	3,971	46.2	1	1
Sex	Male	5,893	63.7	3,361	36.3	1.24***	1.13–1.35
	Female	5,170	58.6	3,648	41.4	1	1
Vitamin A supplementation	Twice	6,445	61.4	4,048	38.6	1	1
	Once	3,076	60.0	2,048	40.0	0.94	0.85–1.05
	Never	1,541	62.8	913	37.2	1.06	0.93–1.21
Antenatal care visit	<4 sessions	937	61.5	586	38.5	1.01	0.87–1.18
	≥4 sessions	10,126	61.2	6,423	38.8	1	1
Gestational age	<37 weeks	3,243	63.1	1,897	36.9	1.12*	1.01–1.23
	≥37 weeks	7,820	60.5	5,113	39.5	1	1
Maternal's age	Young (15–24 years)	1,596	61.8	986	38.2	1.01	0.86–1.16
	Middle (25–34 years)	5,973	60.8	3,858	39.2	0.95	0.87–1.05
	Late (≥35 years)	3,493	61.7	2,165	38.3	1	1
Maternal's education	Low	6,047	62.1	3,691	37.9	1.22**	1.06–1.40
	Middle	3,730	61.2	2,360	38.8	1.18*	1.02–1.36
	High	1,286	57.3	958	42.7	1	1
Maternal's occupation	Civil servant/private employer	2,464	57.9	1,795	42.1	0.84**	0.75–0.94
	Entrepreneur	976	66.1	502	33.9	1.19*	1.04–1.37
	Laborer	583	62.7	347	37.3	1.03	0.81–1.30
	Other	825	59.9	553	40.2	0.91	0.78–1.07
	Unemployed	6,215	62.0	3,812	38.0	1	1
Maternal's mental health	CMD (score ≥8)	10,444	71.9	242	28.1	1.66***	1.32–2.08
	Non-CMD (score <8)	618	60.7	6,768	39.3	1	1
Access to drinking water and sanitation	Improved	1,902	58.4	1,354	41.6	1	1
	Poor	9,161	61.8	5,656	38.2	1.15*	1.02–1.30
Type of residence	Urban	6,196	60.1	4,122	39.9	1	1
	Rural	4,867	62.8	2,887	37.2	1.12*	1.03–1.23
Number of household members	<5 people	6,350	59.6	4,306	40.4	1	1
	≥5 people	4,712	63.5	2,704	36.5	1.18***	1.08–1.29

Notes: OR = Odds Ratio, CI = Confidence Intervals, CMD = Common Mental Disorders, *p-value<0.05, **p-value<0.01, ***p-value<0.001



Notes: S = Stunted, SU = Stunted-Underweight, SWU = Stunted-Wasted-Underweight

Figure 2. Forest Plot of Odds Ratios for Chronic-Acute Nutritional Status, Antenatal Care, and Access to Drinking Water and Sanitation Concerning the Cognitive Development of Children Aged 36-59 Months in Indonesia (2018)

Table 4. Association Between Composite Index of Anthropometric Failure and Early Childhood Cognitive Development in Indonesia (n = 18,072)

Composite Index of Anthropometric Failure (No Failure as the Reference Group)	Model 1 aOR (95% CI)	Model 2 aOR (95% CI)
No Failure	1	1
Underweight	1.15 (0.85–1.55)	1.15 (0.85–1.58)
Wasted	0.65**(0.50–0.85)	0.65**(0.49–0.85)
Stunted	1.12 (0.98–1.27)	1.09 (0.95–1.23)
Underweight and wasted	0.88 (0.69–1.13)	0.86 (0.68–1.10)
Stunted and underweight	1.33*** (1.15–1.54)	1.31***(1.13–1.52)
Stunted, wasted, and underweight	1.24 (0.90–1.70)	1.16 (0.85–1.58)
n	18,072	18,072
Pseudo R2	0.019	0.027
AIC	23,701.3	23,544.3

Notes: CI = Confidence Interval, aOR = Adjusted Odds Ratio, *p-value<0.05, **p-value<0.01, ***p-value <0.001, AIC: Akaike Information Criteria.
Model 1: Adjusted for child's age. Model 2: Adjusted for child's age, sex, vitamin A supplementation, ANC visits, type of residence, gestational age, access to drinking water and sanitation*mother's education, mother's mental health*mother's occupation, and number of household members. (*) indicates significant combined risk between the interaction variables.

(CI 95% = 1.03–1.32) higher risk of this condition than those with normal nutritional status. While, children with wasted nutritional status had a 44% chance of optimal cognitive development.

Other variables that were significantly related to cognitive development were sex (OR = 1.24; 95% CI = 1.13–1.35), gestational age (OR = 1.12; 95% CI = 1.01–1.23), maternal's education (low and middle) (OR = 1.22; 95% CI = 1.06–1.40 and OR = 1.18; 95% CI =1.02–1.36), maternal's occupation (entrepreneur and civil servant/private employer) (OR = 1.19; 95% CI = 1.04–1.37 and OR = 0.84; 95% CI = 0.75–0.94), maternal's mental health (OR = 1.66; 95% CI = 1.32–2.08), access to drinking water and sanitation (OR = 1.15; 95% CI = 1.02–1.30), type of residence (OR = 1.12; CI 95% = 1.03–1.23), and number of household members (OR = 1.18; 95% CI = 1.08–1.29). Conversely, vitamin A supplementation, ANC visits, and mother's age were not significantly associated with ECCD (p-value>0.05).

Interactions between variables in relation to ECCD were also identified in this study. For instance, stunted children with a record of <4 ANC visits and poor access to drinking water and sanitation were at higher risk of delayed childhood cognitive development (OR = 5.41; CI 95% = 1.08–27.03; p-value = 0.040). The range of CI values from the OR crude interaction of these variables significantly impacted ECCD compared to other interaction categories (Figure 2). Nevertheless, the wide range of OR crude CI values indicates large data variability. Therefore, the OR crude number of the interaction between variables was less accurate as a parameter in the population. However, this finding highlighted the combination of risk factors that should be explored in future studies on cognitive development among children.

Based on Table 4, the parsimony model has a Pseudo R2 value close to 1, and the smallest Akaike Information Criteria value was determined in model 4. The CIAF (wasted and stunted-underweight) had a significant rela-

tionship with ECCD after controlling for variables, which included child's age, sex, vitamin A supplementation, ANC visits, gestational age, access to drinking water and sanitation (combined risk), maternal's education and mental health (combined risk), maternal employment and number of household members (combined risk).

Discussion

This study discovered that a stunted-underweight child was most likely to experience a disruption in ECCD. These results aligned with studies that reported that children's nutritional status at the population level (stunting and underweight-stunting) is the most significant predictor of delays in early childhood development.[11,23] Children are vulnerable to diseases and malnutrition in the early stages of life, reducing their immunological capacity against illnesses that could impact daily cognitive, physical, and mental growth and development.[24]

This study revealed that ECCD of younger children (36-47 months) differed from older children (48-59 months). Cognitive development occurs rapidly at the age of under five years due to brain growth and child neurodevelopment.[25] A child's brain development is in line with age, evident from the multiple intercell connectivity propagations.[26]

Anatomically, younger children experience slower cognitive development than older children. Therefore, nutritional status based on the height for age index could negatively impact children's central nervous system and other functional development that might persist throughout their lifetime.[17] Another study also found that the effect of a stunted nutritional status was not limited to cognitive development deficits but also communication and motor development.[27] These results highlight the importance of integrated interventions that support good nutrition, particularly in children who suffer from nutritional problems, in addition to other anthropometric measurements.[27]

Children with wasted nutrition had a 44% lower chance of experiencing delayed cognitive development. These findings were consistent with a previous study where the z-score for wasted children exhibited a nonlinear relationship with child development deficits.[27] Nonetheless, these results should be reconsidered as this study utilized a cross-sectional design; there was a tendency that the children were not in good health or susceptible to disease due to acute malnutrition (wasted) when cognitive development was measured.

One measure of cognitive development is the child's ability to read and count, which significantly impacts children's short and long-term development.[28] If a child suffers from acute malnutrition, the results of the cognitive development index are biased due to the child's inability to fulfill the criteria of cognitive development.[29] A previous study showed that nutritional status (underweight, stunted, and not wasting) significantly influences ECCD.[17]

A child with wasted nutritional status is highly likely to have poor communication and social skills.[30] While, underweight-wasted and stunted-wasted-underweight nutritional status were not significantly associated with ECCD. This finding may result from the low prevalence of underweight and wasted children in this study and acute or temporary incidence (compared to the cumulative impact/effect of stunting).[31]

Underweight and stunted boys were more susceptible to cognitive development delays than girls. This finding confirms that girls had an advantage in cognitive-motor and socio-emotional development compared to boys.[32] Furthermore, girls are superior to boys in functional brain development related to communication and language development.[33]

Children aged 36-47 months also had the potential to experience cognitive development later than those between 48-59 months. Cognitive development under five years is developing rapidly despite the slight time difference.[25] The first 1,000 days of a child's life were initially deemed the most critical period for brain development and growth,[34] but this study's results demonstrated that the next 1,000 days were equally critical for cognitive development.

No significant relationship between vitamin A supplementation and cognitive development was found in this study. Essential micronutrients are not limited to vitamin A but also include zinc supplementation and deworming in children who are at risk.[35] In addition, children with nutritional deficiencies who received consistent micronutrient supplements exhibited significant improvements in cognitive outcomes.[34]

Children born at a gestational age of <37 weeks had smaller and less mature brains, poor social-emotional development at two years old, poor school readiness and increased special educational needs, and increased respiratory morbidity in infancy and early childhood.[36] Pregnancy is often associated with susceptibility to infection.[37] Furthermore, poor access to drinking water and sanitation results in unsafe and unhealthy food. When mothers do not consume proper nutrition during pregnancy, children born <37 weeks will potentially experience delays in cognitive development at 36-59 months.[38]

Early childhood with highly educated mothers generally contributes to good development in all domains, including literacy-numeration, physical, learning, and social-emotional.[21,39] Mothers with higher education backgrounds tended to be more aware of the importance of maintaining child development, such as cognitive development, and hence are proactive in seeking information and providing suitable interventions to sup-

port optimal child development. While, mother's mental health can predict children's academic achievement, a measure of the human development index in the economic sector.[40] This study found that mothers with mental disorders suffered from emotional turmoil and faced challenges in providing the best care for a child's optimal cognitive development.

Unemployed mothers might not contribute to the family's income. Consequently, providing quality and safe nutrition might be difficult in a family of ≥5 people. Another study also reported that mothers who are civil servants/private employees are a protective factor against delays in cognitive development.[21] Thus, children with mothers who were full-time homemakers and had ≥5 household members were more vulnerable to experiencing delays in cognitive development and stunted-underweight nutritional status.

This study had several limitations. First, the 2018 IBHR offered cross-sectional data; thus, causality relationships could not be identified. Second, the 2018 IBHR utilized multistage sampling within the same cluster, potentially leading to significantly homogenous participants. Data collection at a higher level (population level) for analyses could result in the ecological fallacy, where the conclusion drawn at the group level might not apply to the individuals within the group.

Third, the CIAF only applied to children under the age of five and did not consider obesity. Fourth, the number of covariates obtained in the 2018 IBHR was limited. This study could not explore additional essential variables that reportedly influence a child's growth and development, such as hidden hunger (more variables for micronutrient supplementation), maternal knowledge about vitamin A supplementation, poverty index, and parenting style.

Conclusion

This study's findings demonstrate a significant relationship between numerous anthropometric failures and ECCD. The significant negative relationship between wasted and ECCD after controlling for variables such as child's age, sex, vitamin A supplementation, ANC visits, gestational age, access to drinking water and sanitation (combined risk), maternal's education and maternal's mental health (combined risk), maternal's occupation and number of household members (combined risk). Future studies should perform a multilevel model analysis to account for the clustering and hierarchical structure and manage variations between clusters.

Abbreviations

ECDI: Early Childhood Development Index; IBHR: Indonesian Basic Health Research; CIAF: Composite Index Anthropometric Failure; ECCD: Early Childhood Cognitive Development; ANC: Antenatal Care; CMD: Common Mental Disorder; OR: Odds Ratio; AOR: Adjusted Odds Ratio; CI: Confidence Interval.

Ethics Approval and Consent to Participate

This study received an ethical eligibility letter from the Biomedical Research Ethics Commission on Human, Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada, on 31 January 2023 No. KE/FK/0148/EC/2023.

Competing Interest

The author declared that no significant competing financial, professional, or personal interest might have affected the performance or presentation of the work described in this manuscript.

Availability of Data and Materials

The data used in this study were not publicly available. A reasonable request for the dataset can be sent to Badan Kebijakan Pembangunan Kesehatan of the Indonesian Ministry of Health.

Authors' Contribution

SZ was responsible for the entire process, including the analysis, writing, and revision of the manuscript. AW was responsible for the conceptualization, and RKH was responsible for revising the manuscript.

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Role of Partner and Health Workers on Modern Contraceptive Use Among Married/In-union Women in Uzbekistan

Supriatin[1], Mohamed Rifky[2], Muhammad Uzair Khan[3], Lili Amaliah[4], Marlynda H N Sari[5], Eko Budi Santoso[6], Indra Ruswadi[7], Maretalinia[8], Linda Suwarni[9]

[1]Nursing Science Program, Sekolah Tinggi Ilmu Kesehatan Cirebon, Cirebon, Indonesia, [2]Tashkent Chemical Technological Institute, Uzbekistan, [3]International Medical Faculty, Samarkand State Medical University, Samarkand, Uzbekistan, [4]Public Health Program, Institut Teknologi dan Kesehatan Mahardika, Cirebon, Indonesia, [5]Midwifery Program, Politeknik Kesehatan Kementerian Kesehatan Semarang, Semarang, Indonesia, [6]Nursing Professional Program, Institut Kesehatan dan Bisnis Surabaya, Surabaya, Indonesia, [7]Nursing Program, Politeknik Negeri Indramayu, Indramayu, Indonesia, [8]Ph.D. Program in Demography, Institute for Population and Social Research, Mahidol University, Thailand, [9]Faculty of Health Science, Universitas Muhammadiyah Pontianak, Pontianak, Indonesia

Abstract

Many factors contribute to the declining total fertility rate, including family planning programs. The successful implementation of the family planning method might be influenced by how the decision to choose a contraceptive method was made. This study aimed to examine the correlation between family planning decision-makers and modern contraceptive use among married/in-union women of reproductive age in Uzbekistan. The 2021-2022 Multiple Indicator Cluster Survey was used by selecting only married/in-union women of reproductive age of 15 to 49 years, totaling 2,794 eligible samples. The modern family planning use variables were divided into not using, using Long-Acting Contraceptives (LAC), and Short-Acting Contraceptives (SAC). The univariate, bivariate (Chi-square and ANOVA), and multinomial logistic regression were performed. Family planning decision-makers from both women and husbands/partners, health workers, or others were significantly associated with modern contraceptive use for SAC and LAC, respectively. The type of family planning methods was significantly influenced by decision makers. Spouses, family members, and health workers need to implicate women to decide the most applicable contraceptive method.

Keywords: long-acting contraceptives, modern contraceptive methods, Multiple Indicator Cluster Survey, short-acting contraceptives, Uzbekistan

Introduction

Uzbekistan is a Central Asian country that became independent from the Soviet Union in 1991. During the starting phase, Uzbekistan reformed the economic and health sector, focusing on women's health.[1,2] Woman and child health is still a concern in developing countries, including Uzbekistan.[3] Regarding family issues, contraception is necessary for economic development, human rights issues, and women's health.[4] Women of reproductive age face many potential risks due to biological processes, including pregnancy. Women have the autonomy to plan when and how many children they want, affecting their health and social well-being. The ability of women to control their fertility is representative of women's empowerment toward their roles, rights, and status.[4]

Despite the traditional method, modern use is more interesting because it includes barriers and hormonal methods, emergency contraception, and sterilization; thus, high promotion in terms of rationalization, science, and global focus.[4] Uzbekistan, where Muslims dominantly reside, still focuses on seeking legal justice.[3] As an individual, women are treated unequally in every society, including in Uzbekistan.[1] In a patriarchal society, Uzbekistan turned to a new chapter to raise the issue of gender equality and the powerless status of women to obtain equality in male-dominated societies and families.[3] Sometimes, a religious issue is raised for using long-acting reversible contraceptives (LARC), especially sterilization.[1]

According to the Family Planning 2020 (FP2020) Uzbekistan Fact Sheet, the modern contraceptive prevalence, unmet need for modern contraception, and demand for modern contraception were 49.4%, 13%, and 83.2%, respectively.[5] In 2020, an estimated total of 4,414,000 women applied a modern contraception in Uzbekistan, and most of them used intrauterine devices (IUDs).[5] In Uzbekistan, women are facing cultural norms and gender stereotypes.[6] Women's rights and position in society are based on individual development, experiences, and activity, including women's power to con-

Correspondence: Supriatin, Nursing Science Program, Sekolah Tinggi Ilmu Kesehatan Cirebon, Brigjend Dharsono Street No.12b, Kertawinangun, Kedawung Subdistrict, Cirebon District, West Java 45153, Indonesia, Email: supriatin98@yahoo.co.id, Phone: +62 813-2428-7174*

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trol fertility.[7] A high fertility rate occurred during Sovietism, making abortion a form of birth control instead of contraceptives.[3] However, after being independent from the Soviet Union, it declined from 6.9 in 1962 to 2.2 in 2012, but steadily increased to 3.2 in 2021.[8]

According to the FP2020 data, 67.9% of women in Asia were satisfied with modern contraceptive methods.[9] Globally, the prevalence of modern contraception methods was associated with women's age and education level.[10] However, related studies did not distinguish modern contraception in long-acting contraceptives (LAC) and short-acting contraceptives (SAC), which is important to examine because of time considerations. The shared decision-making approach has been a tool to define the use of modern contraceptives.[11] In Uzbekistan, the government encourages women to use modern contraceptives such as IUDs and sterilization.[12]

In Central Asia and India, limited studies have examined the correlation between decision-makers and family planning choices. Related studies in Tajikistan and India found that most women's authority to choose the type of contraceptive method could be higher if they exhibited control over their health care and financial support.[13] In the Uzbekistan context, this is the only study examining the correlation between family planning decision-makers and modern contraceptive use. Most related studies aimed at finding the determinants of family planning use, not specifically through the role of the decision maker.

This study aimed to examine the correlation between the family planning decision-maker and modern family planning use among married/in-union women of reproductive age in Uzbekistan. Modern contraceptive use in this study was divided into long- and short-term use according to time duration. This study will contribute to respecting women's authority, especially in a society where patriarchal systems are mostly employed. Women's rights issues were also brought out by this study to support the achievement of Sustainable Development Goal Five: to achieve gender equality and empower all women and girls.

Method

The State Committee of the Republic of Uzbekistan on Statistics and the United Nations Children's Fund (UNICEF) Uzbekistan Country Office implemented the Multiple Indicator Cluster Survey (MICS) second cycle, providing secondary data for this cross-sectional study. The academics must register and submit a brief justification of their study plan to access the dataset. After two to four working days of processing, the authorization to access the data was emailed. The MICS was one of the main sources of data concerning mothers and children, and the data were gathered between November 2021 and January 2022.

Three-stage stratified sampling was the design strategy adopted. A total of 14 regions, both urban and rural, were selected to collect data. In Uzbekistan, the six geo-economic regions include the Western (Republic of Karakalpakstan, Khorezm Region), Central (Jizzakh, Syrdarya and Tashkent Regions), Southern (Kashkadarya and Surkhandary Regions), Central-Eastern (Bukhara, Samarkand and Navoi Regions), Eastern (Fergana, Andijan and Namangan Regions) and Tashkent City. MICS sought to evaluate the state of women and children in the nation following international models and criteria to enable cross-national comparison. As many as 4,448 households were the focus of the MICS in Uzbekistan. In 2021, 10,879 homes in 556 clusters completed interviews with the household head and all other members.

For this study, the total sample of women aged 15 to 49 years was 5,068 eligible, and 4,772 were interviewed. The inclusion criteria to select a sample for this current study were women aged 15 to 49 years, currently living with husbands or partners, and completely interviewed. Women not completely interviewed or refused during the interview were excluded. The final sample for this study totaled 2,794 women after data cleaning and excluding missing data in each variable. The formerly married/in-union (single, divorced, separated, and widows) were excluded from the analysis because this study only focused on married women of reproductive age.

Four types of questionnaires were used to include households, women aged 14 to 49 years old, children under the age of 5, and children aged 5 to 17 years.[14] This study only focused on women's questionnaires. The women's questionnaire asked for women of reproductive age (15 to 49 years). In that questionnaire, women were asked about the fertility/record of birth, desire for last birth, maternal and newborn health, checking for postnatal, unmet needs, contraception, domestic violence, victimization, marriage, reproductive health, adult functioning, and HIV/AIDS status. The original questionnaire was in English and Russian but customized and translated into Uzbek and Karakalpak languages.

In September 2020, the preliminary study was conducted in one urban and rural mahalla in Karakalpakstan and Tashkent City, and one rural mahalla in the Tashkent Region. The translation and wording of the questionnaires were changed in response to the findings of the pre-tested survey. According to the dependent variable, the exact question is, "Would you say that using contraception is mainly your decision, mainly your husband's or partner's decision, did you both decide together, or is it the decision of a health care worker?". The options provided include mainly respondent (women), mainly husband/partner, the joint decision of respondent and husband/partner, and health workers/others.

The Health Media Lab's Ethical Review Board ap-

proved the MICS Uzbekistan survey procedure in March 2020.[14] The protocol comprised a protection policy covering potential dangers throughout the survey's life cycle and management techniques to reduce them. The data collection used Computer-Assisted Personal Interviewing (CAPI) and Census and Survey Processing System (CSPro) Software, Version 6.3. Data were aggregated cluster by cluster to create the final datasets, processed using CSPro, and analyzed using SPSS. All software used for MICS was under the UNICEF license. The MICS Uzbekistan constituted an open-access dataset with registration required. The dataset and all documentation can be downloaded on https://mics.unicef.org/surveys.[15]

The dependent variable was the use of modern contraceptive methods divided into three categories: not using, using LAC, and using SAC. The LAC was defined as women using IUDs, implants, and sterilization, while SAC was defined as using pills, injections, condoms, diaphragms, and jelly/foam. The main independent variable was the decision maker for family planning choice, which was divided into women only, husband/partner only, women and husband/partner, and health worker or others. The covariates included in the model comprised women's age, marital status (living with husband/living with a partner), educational level (primary/secondary, vocational and higher), husband/partner's age, wealth index (poorest, poorer, middle, richer and richest) and residence (urban/rural).

The univariate, bivariate, and multivariate analysis was tested using STATA Software, Version 17, licensed for the Institute for Population and Social Research, Mahidol University, Thailand. The univariate analysis aimed to find the general description of the respondents. The categorical variables were presented in percentage and frequency, and continuous variables were presented by minimum, maximum, mean, and standard deviation. The bivariate analysis aimed at testing the correlation between independent and dependent variables. It used the Chi-square test for categorical predictors and the analysis of variance (ANOVA) test for continuous predictors and used a 95% confidence interval (CI) to define the significance. Multivariate analysis aimed at testing the correlation between the main independent and dependent variables by adjusting with other independent variables. The multivariate analysis was performed using multinomial logistic regression as the dependent variable consists of a nominal scale.

Results

Table 1 describes the general information on the respondents. Regarding modern contraceptive use, most respondents used LAC (63.71%), compared to those using SAC and not using both. According to the family planning decision maker for selecting the method, most respondents reported that both women and husbands or partners decided on the contraceptive method (55.15%). In terms of education level, most respondents graduated from vocational school (49.86%). Almost all were residing with husbands (99.50%), richer wealth index (21.47%), and resided in rural areas (52.79%). According to women's age, their minimum and maximum ages were 18 and 49 years, respectively, with an average of 34.18 years. In terms of husband's/partner's age, the minimum and maximum ages were 19 and 85 years, respectively, with an average of 37.68 years.

Table 2 describes the Chi-square and ANOVA analysis, which found a significant association in the family planning decision maker variable, women's age, marital status, residence, and husband's age. For the variable of decision makers, the highest proportion was found of women and husbands/partners as the decision makers for the SAC family planning method (60.91%). The mean women's age was 34.18, and the husband's/partner's age was 37.68 years old. Regarding education level and contraceptive use, the highest proportion graduated from vocational school and did not use any family planning methods (53.02%). Regarding marital status, the highest proportion was living with their husband/partner and using LAC (99.78%).

The wealth index variable found that the richest index and those using SAC constituted the highest proportion (28.64%). Regarding residence, most women resided in rural areas and used LAC (54.49%). The mean of women's and husbands'/partners' ages was 34.18 and 37.68, respectively. The standard deviation, p-value, and adjusted R-squared for the variable of women's age were

Table 1. Respondents' General Information (n = 2,794)

Variable	Category	n	%
Modern contraceptive use	Not using	794	28.42
	Using SAC	220	7.87
	Using LAC	1,780	63.71
Main decision maker	Women only	967	34.61
	Husband/partner only	130	4.65
	Both women and husband/partner	1,541	55.15
	Health workers or others	156	5.58
Women's education level	Primary and secondary	1,080	38.65
	Vocational	1,393	49.86
	Higher	321	11.49
Marital status	Living with husband	2,780	99.50
	Living with partner	14	0.50
Wealth index	Poorest	531	19.01
	Poorer	523	18.72
	Middle	552	19.76
	Richer	600	21.47
	Richest	588	21.05
Residence	Urban	1,319	47.21
	Rural	1,475	52.79

Notes: SAC = Short-acting Contraceptive, LAC = Long-acting Contraceptive

Table 2. Bivariate Analysis of the Correlation Between Family Planning Decision Maker and Modern Contraceptive Use (n = 2,794)

Variable	Category	Modern Contraceptive Use (n, %)			p-value
		Not Using	SAC	LAC	
Main decision maker	Women only	290 (36.52)	62 (28.18)	615 (34.55)	0.001**
	Husband/partner only	41 (5.16)	16 (7.27)	73 (4.10)	
	Both women and husband/partner	436 (54.91)	134 (60.91)	971 (54.55)	
	Health workers or others	27 (3.40)	8 (3.64)	121 (6.80)	
Women's education level	Primary and secondary	275 (34.63)	84 (18.18)	721 (40.51)	0.068
	Vocational	421 (53.02)	107 (48.64)	865 (48.60)	
	Higher	98 (12.34)	29 (13.18)	194 (10.90)	
Marital status	Living with husband	786 (98.99)	218 (99.09)	1,776 (99.78)	0.023*
	Living with partner	8 (1.01)	2 (0.91)	4 (0.22)	
Wealth index	Poorest	160 (20.15)	39 (17.73)	332 (18.65)	0.092
	Poorer	150 (18.89)	37 (16.82)	336 (18.88)	
	Middle	141 (17.76)	42 (19.09)	369 (20.73)	
	Richer	168 (21.16)	39 (17.73)	393 (22.08)	
	Richest	175 (22.04)	63 (28.64)	350 (19.66)	
Residence	Urban	393 (49.50)	116 (52.73)	810 (45.51)	0.040*
	Rural	401 (50.50)	104 (47.27)	970 (54.49)	

Notes: SAC = Short-Acting Contraceptives, LAC = Long-Acting Contraceptives, p-value<0.05, **p-value<0.01, ***p-value<0.001

Table 3. Result of Multinomial Logistic Regression of Modern Contraceptive Use (n = 2,794)

Variable	Category	Short-Acting Contraceptive			Long-Acting Contraceptive		
		RRR	Lower	Upper	RRR	Lower	Upper
Main decision maker	Women only	Ref			Ref		
	Husband/partner only	1.86	0.97	3.57	0.87	0.57	1.33
	Both women and husband/partner	1.58**	1.12	2.23	1.13	0.94	1.37
	Health workers or others	1.51	0.65	3.51	2.16**	1.37	3.39
Women's age		1.07**	1.02	1.12	1.12***	1.09	1.15
Women's education level	Primary and secondary	Ref			Ref		
	Vocational	1.13	0.79	1.62	1.18	0.96	1.45
	Higher	1.03	0.61	1.74	0.97	0.71	1.33
Marital status	Living with husband	Ref			Ref		
	Living with partner	0.81	0.16	3.99	0.19**	0.06	0.67
Wealth index	Poorest	Ref			Ref		
	Poorer	1.01	0.61	1.68	1.07	0.81	1.42
	Middle	1.27	0.77	2.09	1.31	0.98	1.73
	Richer	1.07	0.65	1.79	1.31	0.99	1.73
	Richest	1.53	0.91	2.58	1.12	0.82	1.52
Residence	Urban	Ref			Ref		
	Rural	1.01	0.71	1.41	1.14	0.94	1.38
Husband's age		0.99	0.95	1.04	0.97**	0.94	0.99

Notes: RRR = Relative Risk Ratio, p-value<0.05, **p-value<0.01, ***p-value<0.001

7.71, <0.001, and 0.0765, respectively. The standard deviation, p-value, and adjusted R-squared for the variable of husband/partner's age were 8.01, <0.001, and 0.0603, respectively.

Table 3 displays the results of multinomial logistic regression. The factors found significantly related to the use of SAC were both side decision making and women's age. The relative risk ratio comparing women as the only decision maker for the family planning method and both women and husband/partner as the decision maker was 1.58 for not using versus using SAC. In other words, the expected risk of using SAC was higher for both women and husband/partner as the decision makers for family planning methods. In terms of women's age, the relative risk ratio for a one-year increase in women's age was 1.07 for using SAC compared with those not using the family planning method. Therefore, older woman's age exhibited a higher tendency to use SAC by 1.07 times.

The factors associated with using LAC were health workers or others as decision makers for choosing the family planning method, women's age, living with a partner, and husband's/partner's age. The relative risk ratio

comparing women as the only decision makers for family planning and health workers or others as decision makers was 2.16 for not using versus using LAC. The relative risk ratio comparing women living with husbands and living with a partner was 0.19 for not using versus using LAC. In other words, the expected risk of using LAC was higher for health workers or others as decision makers and lower for women living with partners than women living with husbands.

In terms of women and husbands' ages, for a one-year increase, women's age was 1.12 for using LAC versus not using the family planning method. However, the one-year increase in the husband's age was 0.97 for using LAC versus not using. In other words, the relative risk ratio of using LAC was higher for health workers or other decision makers and women older by age. However, LAC was lower for women living with partners and husbands older by age. However, in the multivariate analysis, the remaining variables were not associated with using modern contraceptive methods.

The family planning decision maker was the main predictor in this study, and the probability of choosing a modern family planning method is displayed in Figure 1. It captures the margins plot for three possible outcomes based on the decision maker. According to the Figure 1, it can be concluded that the husband/partner only is the most influential variable for not using any contraceptive method and for using SAC methods such as pills, injections, foam/jelly, and diaphragm. However, using the LAC was mostly influenced by health workers as decision makers.

Discussion

The family planning method is directly implemented to control birth.[3] According to the World Bank data, the total fertility rate in Uzbekistan declined from 6.9 in 1962 to 2.2 in 2012, but steadily increased to 3.2 in 2021.[8] The family planning method used by women of reproductive age in Uzbekistan is quite high, especially women using IUDs (higher than 80%).[5] The government's role is to establish a policy to control birth, such as motivating women who have given birth to two or more children to sterilization and persuading young women to use IUDs.[16]

This study revealed that the percentage of LARC was higher than SAC because the timing was considered to control the birth. Women using IUDs, implants, or sterilization might apply those methods for the long term, compared to SAC, including pills, injections, or condoms that could only be used in the short term.[9] The high percentage of sterilization and IUDs is also decidedly attributed to medical doctors and health professionals who educate women and families about the importance of family planning methods and improve healthcare provision to encourage women to space out births and limit children to only two.[10] According to the United Nations Population Fund classification, Uzbekistan needs to control its population growth because it placed this country in the three poorest in the former Soviet Union according to per capita income.[2]

This study revealed that the factors associated with modern contraception were decision makers and women's age. However, for the LAC, the additional factors

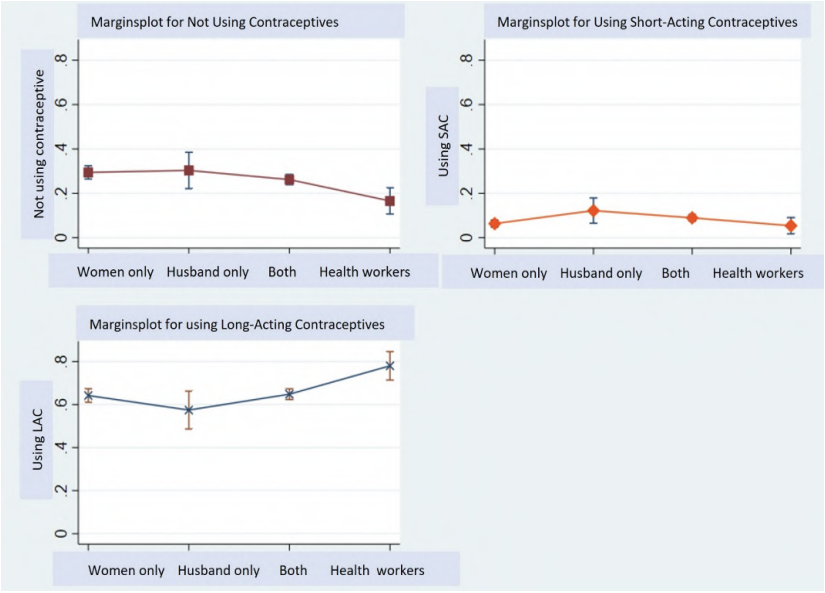

Figure 1. Adjusted Predictive of Mainly Family Planning Decision Maker with 90% Confidence Intervals

included living with a partner/in a union and the husband's/partner's age. Decision-making in the family presented the autonomy of both sides, husband and wife. The patriarchy is one possible reason that could be linked between reproductive and informal work or other aspects, including how the decision is made.[17] Uzbekistan is a country that prefers having sons rather than daughters.[3] Hence, the number of children in Uzbekistan families before the success of the family planning program was five to ten children.[16]

One study in Uzbekistan summarized the effect of patriarchy on women, such as women being afraid to gain awareness of their legal rights and that violations will not end due to divorce.[18] Uzbek women received unequal awareness of formal rights and socioeconomic transformation because of the high number of the unemployed, low level of education, and poverty.[19] In Uzbekistan, women are not represented or invisible because of cultural norms and gender stereotypes.[6] The position of women in society is based on individual development through experience and activity.[7]

The record of birth control in Uzbekistan started with the standard Soviet method, abortion, and the culture seems to make women afraid not to give birth every year because the husband and family members might cease to care for them, and the wife will lose face.[3] IUD is the method women use in Uzbekistan because of the national reproductive health program, and women possess little knowledge and experience with methods other than IUD.[5] In this study, both decision makers significantly chose SAC. However, for LAC, the health worker's decision dominated. The government seriously motivated health workers to encourage women to use IUDs immediately after giving birth and use sterilization after having two children.[1]

Other variables influencing modern family planning methods were women's age, living with a partner, and husband's/partner's age. Women at increasing age tend to use modern family planning to prevent pregnancy, which might be at high risk.[20,21] The risk is to both the women's and the newborn's health. Women living with a partner or in a union were less likely to use LAC modern contraceptive methods because health insurance may not cover those methods.[20] However, the SAC contraceptive methods are free, so that women are more likely to use SAC or traditional contraceptives.[20] Increasing husband's/partner's age makes it less likely to use modern family planning methods.[22,23] It might be due to the children's sex preference that drives the husband to have a son even though the wife has already given birth to daughters many times.

The power of women's decision-making was influenced by age, literacy, the number of children, and socioeconomic status.[24] Joint decision-making between women and husband/partner was found to have a strong power compared with women only.[25] Nigerian women also participated in household decision-making and could decide on their fertility.[26] One study in South Africa found a correlation between culture and men making decisions regarding child-bearing.[27] Female as the decision maker was associated with a higher tendency to use contraceptives and a limited number of children.[28]

The decision-maker of contraceptive use is an iterative, relational, reflective journey and dynamic process that can change over time.[29] Contraceptive attributes affected family planning decision-making, and none drove most women's decisions.[30] Decision-making between wife and husband was less likely to have an unmet need for contraception.[31] Women's empowerment was also significantly related to the use of contraception.[32] Many factors may encourage women to use contraceptives, such as level of education, the number of children, and acceptance of family members.[33] Women's autonomy was a strong predictor of modern contraceptive use based on studies in Indonesia.[34,35] However, the male partner's decision sometimes constitutes a barrier instead of influencing family members and friends.[36]

In line with related studies, in Sub-Saharan Africa, the contribution of males in the family planning program was very low in decisions and implementation.[37] Women's choice of contraceptive methods is influenced by the effectiveness in preventing pregnancy, HIV/Sexually Transmitted Diseases (STDs), and hormone-free status.[38] Even though health workers played the role of educating women regarding the pros and cons of each contraceptive method, the participation of peers was dominant.[39] Many tools could be developed as the media of contraceptive counseling, including tablet-based, which found that most women felt choosing the method they wanted was easier.[11] Shared decision-making represents the great engagement between women and health workers, and the outcomes can be evaluated.[11] In conclusion, SAC use was significantly influenced by decisions from both women and husbands/partners, but health workers significantly influenced SAC use.

Conclusion

The roles of partners and health workers are important in modern contraceptive use. In detail, for LAC methods, the role of the health worker was the most influential. Moreover, the role of both decisions (women and partners) for SAC methods was the most influential. The collaboration between partners and health workers can effectively increase modern contraceptive use.

Abbreviations

LARC: Long-acting Reversible Contraceptives; FP2020: Family Planning 2020; IUD: Intrauterine Device; LAC: Long-acting

Contraceptives; SAC: Short-acting Contraceptives; UNICEF: Nations Children's Fund; MICS: Multiple Indicator Cluster Survey; CAPI: Computer-Assisted Personal Interviewing; ANOVA: Analysis of Variance; CI: Confidence Interval; STDs: Sexually Transmitted Diseases.

Ethics Approval and Consent to Participate

Verbal consent was obtained for each respondent participating. All respondents were informed of the voluntary nature of participation and the confidentiality and anonymity of information. Additionally, respondents were informed of their right to refuse to answer all or particular questions, as well as to stop the interview at any time.

Competing Interest

The authors declare that there are no significant competing financial, professional, or personal interests that might have affected the performance or presentation of the work described in this manuscript.

Availability of Data and Materials

The raw data is available on the website https://mics.unicef.org/surveys.[18] and is free to download after registration and receiving approval.

Authors' Contribution

S, HA, and M obtained and analyzed the data and developed the topics. LA, MHNS, MH, and IR contributed to the study's conceptualization and design. MR and MUH were focused on the background and discussion sections. All authors critically reviewed the manuscript and took part in the discussion part. All authors read and approved the final manuscript.

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Development of an Evidence-Based Tool to Assess the Relative Vulnerability of Different Communities to Tuberculosis

Slamet Isworo[1], Sri Handayani[2*], Reece Hinchcliff[3], Zainal A Hasibuan[4]

[1]Department of Environmental Health, Faculty of Health Sciences, Universitas Dian Nuswantoro, Semarang, Indonesia, [2]Department of of Public Health, Faculty of Health Sciences, Universitas Dian Nuswantoro, Semarang, Indonesia, [3]School of Applied Psychology, Griffith Health Group, Griffith University, Queensland, Australia, [4]Faculty of Computer Science, Universitas Dian Nuswantoro, Semarang, Indonesia

Abstract

Identifying specific tuberculosis (TB) vulnerabilities in populations based on their geographical, demographic, and epidemiological characteristics is an essential yet challenging requirement to help reduce and eliminate TB. Assessment tools that can accurately quantify the risks associated with key factors could be used to measure TB vulnerability efficiently and indicate the most appropriate range of interventions. This study aimed to develop TB vulnerability assessment tools based on a TB vulnerability assessment conceptual framework developed with Leximancer. Three steps to produce the tools were facet analysis, interpreting the facet to create a list of questions, and expert judgment to confirm the suitability of the questionnaire. The "everything is data" principle was used to identify the data sources and build the tools. The data came from multiple primary data sources, with a questionnaire survey and observational form, and secondary data from various governmental statistical departments in Indonesia to collect data related to demography, health indicators, climate, temperature, and air quality. These tools will be optimized at scale next year to evaluate their utility for prioritizing and prescribing health system responses to TB in different communities in Central Java Province.

Keywords: big data, Leximancer, tuberculosis, vulnerability assessment

Introduction

The World Health Organization released the End TB strategy to eliminate tuberculosis (TB) in 2035. The strategy aims to reduce TB incidence to 90%, reduce TB death-related diseases by 95%, and protect families from negative impacts.[1] As of 2022, the target is still far from achieved as the reduction of TB incidence has only reached 10%, death-related TB has only reduced by 5.9%, and 48% of people with TB face catastrophic health expenditure.[2] At the same time, countries with a high burden of TB, such as Indonesia (second highest TB incidence globally), also face additional challenges related to high rates of TB-HIV and TB multidrug resistance.[2]

Indonesia's TB control strategy for 2020-2024 focuses on finding and curing cases through integrated public–private mixed programs and strengthening diagnostic tools.[3] The TB control strategy has been implemented in every city/district in Indonesia, producing variable outcomes.[3] Previous studies have found significant variations in TB risk and outcomes based on the characteristics of communities residing in geographically defined areas.[4-6] The implication is that to accelerate the End TB goal in Indonesia, specific interventions need to be developed and delivered based on each community's unique level and type of TB vulnerability.[7] Even though the vulnerability measurement based on an individual was developed, identifying specific TB vulnerabilities based on area is challenging as no specific guidance is available. Other factors include lacking practical tools and methods to support these efforts and variable access to the required data types.[8]

Developing TB vulnerability assessment tools that quantify the risks associated with unique factors within different communities may facilitate the accurate and efficient measurement of TB vulnerability and guide more effective health and social welfare interventions. Previous studies have proposed strategies to measure TB vulnerability only based on individual factors.[8,9] Another study has measured TB vulnerability by solely relying on social factors analysis.[10] Based on a prior evidence synthesis project,[11] a framework to measure TB vulnerability based on geographical area was developed. This study aimed to extend that body of work by developing specific tools to measure TB vulnerability based on the previous-

Correspondence: Sri Handayani, Department of Public Health, Faculty of Health Sciences, Universitas Dian Nuswantoro, Nakula 1 Street No. 5-11, Pendrikan Kidul, Semarang City, Central Java 50131, Indonesia, Email: sri.handayani@dsn.dinus.ac.id, Phone: +62 811-2680-990*

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ly-created TB vulnerability framework.[11] This study would provide tools to measure the vulnerability of TB in the community and a guide to prioritize and prescribe health system responses to TB based on different risk factors in communities. The use of several concept components in the concept framework allows the comprehensive exploration of the risk factors and helps to establish robust tools for measuring vulnerability based on geographical area.

Method

The TB vulnerability assessment conceptual framework has five components: risk of TB transmission, damage caused by TB, available health facilities, TB burden, and TB awareness.[11] These components required data from individual and health facilities–based data. The individual-based data were the risk of TB transmission (including the level of knowledge, environmental condition, and individual susceptibility), the damage caused by TB (economic impact and social support), and TB awareness (TB literacy). The health facilities–based data were TB burden (the number of TB cases) and the number of health facilities available in the area. The framework was built with Leximancer, a software under the license of Queensland University of Technology (QUT) Australia that uses machine-learning techniques to perform quantitative content analysis.[12] The use of Leximancer as automatic content analysis helps data processing visualize conceptual maps by generating main concepts within the text and determining how they are related. Leximancer enables the analysis of more data more frequently.[13] While the output of the Leximancer analysis showed a collection of the most relevant concepts related to TB risk and reduction, along with their interconnections, these insights could not initially be directly converted into a questionnaire or any other tool that could be used practically to guide TB vulnerability assessment and reduction activities.

To extend this work, three further steps were undertaken to develop methodologically rigorous and practically useful tools: facet analysis, formulation of tools (a questionnaire, an observational form, and a secondary data list), and expert judgment.[14] Facet analysis was undertaken to interpret concepts and translate them into tools (a questionnaire, an observational form, and a secondary data list) to measure each framework component. The resulting concepts were then organized into a logical classification to build a hierarchical structure. Several alternative methods were also undertaken to develop a facet: drawing from Leximancer's topic guide as it is (clear description), structuring several concepts into a make-sense facet (need analysis), and digging deeper into sub-concepts to attain the meaning (need deeper analysis). The three alternatives were used when the concept was built with a more complex meaning of the sub-concept.

A questionnaire was developed in the second stage by interpreting the context created in the facet. One or more assertions were related to each context. The facet not only performed on the theme but also analyzed the quotation result. The questionnaire was created with a series of assertions, a Likert scale asking respondents how much they agree with each statement, and "yes" or "no" answers to knowledge questions. The type of respondent target for each setting and survey topic was likewise carefully examined. This process was repeated until every potential context for each candidate dimension had been discussed. A second analysis examined each question representing each prospective dimension to avoid making repetitive claims. The end outcome was a distributed array of statements for each potential dimension.[15]

This procedure was repeated until each theme's potential contexts had been examined. Further analysis was done to eliminate the likelihood of redundant responses by comparing each theme's questionnaire statements. Based on the component's candidates (risk of TB transmission, damage caused by TB, health facility, TB burden, and TB awareness) created in the previous stage, the resulting statements were automatically sorted into groups. This study employed additional clustering techniques to identify new representable groupings with synchronized and explicit concepts or dimensions. These results aligned with grouping questions with the least amount of redundancy.

In the third step, five experts were invited to evaluate the critical components that resulted from the facet analysis. These experts consist of three lecturers with at least four years of TB research experience until 2022; the lecturers were experts on TB study related to management and intervention. Two worked in the TB field in the Semarang City (Central Java Province, Indonesia) health office, with at least six years of experience until 2022. These two experts were the head of the TB program and the field chief of the TB intervention program in the Semarang City health office. The experts were invited to a meeting, informed of the results of the measurement tools (questionnaire, observation form, and secondary data form), and asked to select each list of questions represented in each TB vulnerability assessment tool component (risk of TB transmission, damage caused by TB, health facility, burden of TB, and awareness of TB).

Results

Figure 1 shows the sample of facet analysis results, for example, how the facet regarding health facilities built the context of services, facilities, systems, and policy.

Besides creating the theme for the analysis output,

Leximancer produced quotations based on the paper analyzed. Table 1 outlines the quotation analysis used to build a context conclusion. For example, the quotation ". . . Treatment completion is understood to depend, in part, on immigrant knowledge and attitudes toward latent TB infection (LTBI) . . ." concludes as level of knowledge context. This result was part of the facet analysis using quotation analysis.

Table 2 shows how the context conclusion is defined (Table 1), and the list of questions and data sources are built. For example, the level of knowledge has three list topics for questions and can be gathered through the survey. The final result of the tools produced three instruments: a questionnaire, an observational form, and a secondary data form (Table 3).

Table 4 presents the observational form for collecting primary data on tuberculosis vulnerability assessment, while Table 5 provides a list of secondary data sources required to measure tuberculosis vulnerability assessment (see below). Table 5 lists the secondary data sources that will be used to supplement the primary data and provide additional insights into tuberculosis vulnerability.

Discussion

This study showed how to measure TB vulnerability with a big data approach to enable the prioritization of specific interventions. The assessment tools produced in this study were based on the big data concept (data gathered from multiple sources) with the principle that "everything is data."[16] While novel to Indonesia, this approach has been applied commonly for disease prevention and control in China and various other countries,

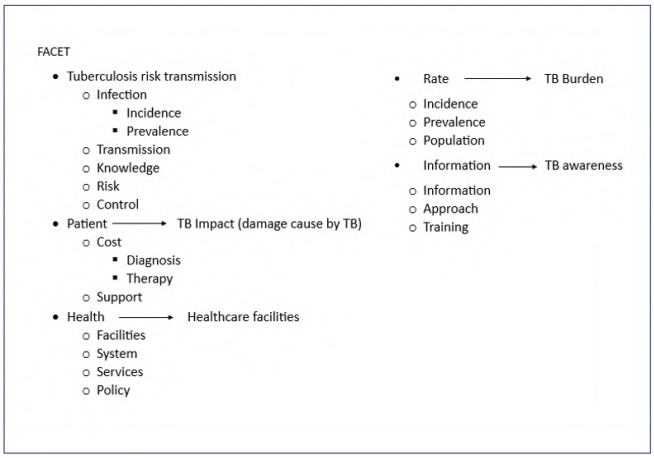

Figure 1. Facet Analysis of Tuberculosis Vulnerability Component

Table 1. Putting Context into Tuberculosis Vulnerability Facets Using Quotation Analysis

Facet	Quotation Example	Context Conclusion
TB risk transmission	. . . Treatment completion is understood to depend, in part, on immigrant knowledge and attitudes toward LTBI . . . . . . Participants with good knowledge of TBIC were three times more likely to practice TBIC than those with poor knowledge . . .	Level of knowledge
TB impact (damage caused by TB)	. . . He did not receive financial support from his family but did mention that the doctor gave him money sometimes . . . . . . Outpatient clinic costs constituted the highest proportion (38.7%) of the total cost, followed by medicine costs (21.6%) . . .	Social support, family support, economic impact

Notes: TB = Tuberculosis, LTBI = Latent Tuberculosis Infection, TBIC = Tuberculosis Infection Control

Table 2. How Facets Developed into the Tuberculosis Vulnerability Assessment Questionnaire

Facet	Context	Definition	Topic for the Question	Source
TB risk transmission	Level of knowledge	Measuring the level of knowledge about TB, including the cause, prevention, and treatment	TB is caused by *Mycobacterium tuberculosis*, which spreads through sputum when people cough How TB can be prevented How TB can be treated	Survey
TB risk transmission	Environmental condition	Measuring the environmental conditions, including humidity, temperature, and housing conditions	House humidity House temperature House condition: floor condition, building condition (permanent, semi-permanent)	Observational
TB risk transmission	Geographical condition	Measuring the geographical condition based on economic status, poverty level, and living density level	Poverty level based on city Population density based on city	Secondary data

Note: TB = Tuberculosis

Table 3. Questionnaire: Tuberculosis Vulnerability Assessment

Variable	No.	Question	Answer Choice	Analytic Expression
Knowledge	1	TB is caused by Mycobacterium tuberculosis, which spreads through sputum when people cough.	Yes / No	Yes: 1, No: 0
	2	If your family member gets a TB infection, you are also at risk of getting an infection.	Yes / No	Yes: 1, No: 0
	3	TB can be prevented when a person closes their mouth when they cough.	Yes / No	Yes: 1, No: 0
	4	TB can be prevented when a person closes their mouth when sneezing.	Yes / No	Yes: 1, No: 0
	5	TB can be prevented by having a BCG vaccine.	Yes / No	Yes: 1, No: 0
	6	TB can be treated by consuming OAT for at least six months.	Yes / No	Yes: 1, No: 0
	7	TB can be resistant if the patient's adherence to taking medicine is low.	Yes / No	Yes: 1, No: 0
Individual susceptibiliy	1	Have you been diagnosed with diabetes mellitus?	Yes / No	Yes: 1, No: 0
	2	Have you been diagnosed with HIV?	Yes / No	Yes: 1, No: 0
	3	Do you have someone in your house diagnosed with diabetes mellitus?	Yes / No	Yes: 1, No: 0
	4	Do you have someone in your house diagnosed with HIV?	Yes / No	Yes: 1, No: 0
	5	Do you have someone in your house diagnosed with TB?	Yes / No	Yes: 1, No: 0
Social support	1	In my community, TB patients are excluded from community gatherings.	Scale from 1 to 7 1: Unlikely 7: Most likely	Score from 1 to 7
	2	In my community, TB patients are more likely to get financial support from the neighborhood.	Scale from 1 to 7 1: Unlikely 7: Most likely	Score from 1 to 7
	3	In my community, TB patients are more likely to get mental support from the neighborhood.	Scale from 1 to 7 1: Unlikely 7: Most likely	Score from 1 to 7
	4	In my community, TB patients are more likely to get social support from the neighborhood.	Scale from 1 to 7 1: Unlikely 7: Most likely	Score from 1 to 7
Family support	1	If my family member gets a TB infection, I will help bring them to a doctor.	Scale from 1 to 7 1: Unlikely 7: Most likely	Score from 1 to 7
	2	If my family member gets a TB infection, I will help do the daily chores.	Scale from 1 to 7 1: Unlikely 7: Most likely	Score from 1 to 7
	3	If my family member gets a TB infection, I will listen to their private worries.	Scale from 1 to 7 1: Unlikely 7: Most likely	Score from 1 to 7
	4	If my family member gets a TB infection, I will show love and affection to them.	Scale from 1 to 7 1: Unlikely 7: Most likely	Score from 1 to 7
Economic impact	1	If my family gets TB, it will affect the family's income.	Scale from 1 to 7 1: Unlikely 7: Most likely	Score from 1 to 7
	2	If my family gets TB, it will affect the family's food consumption.	Scale from 1 to 7 1: Unlikely 7: Most likely	Score from 1 to 7
	3	If I get TB, it will affect my work.	Scale from 1 to 7 1: Unlikely 7: Most likely	Score from 1 to 7
TB literacy	1	How easy is it for you to get information about TB?	Scale from 1 to 7 1: Not easy 7: Very easy	Score from 1 to 7
	2	How easily can you understand the information you get about TB?	Scale from 1 to 7 1: Not easy 7: Very easy	Score from 1 to 7
	3	How often do you use the information to decide the next act?	Scale from 1 to 7 1: Never 7: Always	Score from 1 to 7
	4	How easy is it to process the information into action?	Scale from 1 to 7 1: Not easy 7: Very easy	Score from 1 to 7

Notes: TB = Tuberculosis, BCG = Bacillus Calmette Guerin, OAT = *Obat Anti Tuberculosis* (TB drugs), HIV = Human Immunodeficiency Virus

demonstrating its utility for efficiently and effectively detecting infectious and chronic diseases.[17] The study's findings revealed that big data analytics applications have been beneficial in managing chronic diseases in different stages and could potentially ease the burden of chronic illnesses.

Big data analytics have demonstrated the ability to extract insight from massive data sets and improve out-

Table 4. Observational Form of Tuberculosis Vulnerability Assessment

Subject	Answer
Humidity	Numeric
Temperature	Numeric
Ventilation condition	Bad
	Good
Floor condition	Soil
	Tile
	Carpet
Building condition	Permanent
	Semi-permanent
	Wood
House density	Numeric

Table 5. Secondary Data List for Tuberculosis Vulnerability Assessment

Data	Source
Poverty level based on city	Statistics Indonesia
Population density based on city	Statistics Indonesia
Number of clinics based on city	Health Office
Number of doctor practices based on city	Health Office
Number of pharmacies based on city	Health Office
Number of other health facilities based on city	Health Office
Incidence of tuberculosis based on city	Health Office

comes while minimizing expenses.[15] A previous study identified that the big data approach can be applied to improve chronic disease management, resulting in better outcomes, a lower disease burden, and lower treatment costs.[18] The tools outlined in this study will be able to measure disease burden and, through subsequent action, lower the burden and reduce the cost of prevention and treatment.

Compared to existing instruments, the tools created in this study focused not only on specific factors but also on measuring the complex parameters that can increase the chance of TB transmission. These tools will be able to provide a broader view of risk factors related to TB transmission and combine the analysis with machine learning to give more insight into how all the factors in combination increase the TB vulnerability of communities. A previous tool was provided only for measuring vulnerability in specific conditions related to individual or social vulnerability.[8,10] That has a high chance of failing to acknowledge and account for other factors that may contribute to vulnerability, such as environmental conditions.

Concerning TB prevention at both the global and national levels, one size does not fit all.[19] The mapping of geographical vulnerability, enabled through the tools developed in this study, will help TB program managers identify specific risk factors and build a bespoke array of interventions to decrease TB transmission in specific communities. For example, an education program could be the priority in areas with low TB knowledge, and community engagement may need to be increased in communities with high TB stigma. The same approach has been successfully applied to the education field, resulting in seven clusters of students and providing different interventions based on the risk of each cluster.[16]

One potential bias that might occur in this study was cognitive bias, where the experts' prior knowledge and experience in TB study and intervention might influence their evaluation of the measurement tools. There could also be confirmation bias if the experts only select questions or components that align with their preexisting beliefs or assumptions about TB vulnerability. To minimize the bias, the experts were provided with clear instructions for evaluating the measurement tools and encouraged to base their decisions on available evidence rather than personal opinion or experience. Additionally, a diverse group of experts from various backgrounds was consulted to ensure a broader perspective. Future study is required to explore the validity of the instruments and the framework component in measuring the degree of vulnerability of TB in communities. The big data approach and end-to-end methodology will be used for future investigation.

Conclusion

The application of big data, data linkage, and machine learning has the potential to greatly strengthen current approaches to identifying and reducing TB in vulnerable communities. While the project findings contribute to the increasing body of evidence and practical tools that can facilitate this goal, there are several limitations: there are few expert participants, and the tools have not yet been utilized for policy development purposes, impeding the ability (at this stage) to rigorously determine their validity and reliability, in practice. Future studies are underway to address this limitation.

Abbreviations

TB: Tuberculosis; LTBI: Latent Tuberculosis Infection.

Ethics Approval and Consent to Participate

This study was approved by the Institutional Review Board of Universitas Negeri Semarang (No. 315/KEPK/EC/2023) and performed following the principles of the Declaration of Helsinki. Informed consent was waived because of the retrospective nature of this study.

Competing Interest

The authors declared that there are no significant competing financial, professional, or personal interests that might have affected the performance or presentation of the work described in this manuscript.

Availability of Data and Materials

The datasets are not publicly available but are available from the corresponding author upon reasonable request.

Authors' Contribution

Conceptualization: SI, ZAH, SH; Data curation: SH, ZAH, SI; Formal analysis: all authors; Funding acquisition: SI, SH; Investigation: SI, SH; Methodology: SH, ZAH, RH; Project administration: SH; Resources: RH; Software: RH; Supervision: RH; Validation: ZAH; Visualization: SH; Writing–original draft: SH, SI; Writing–review and editing: all authors.

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The Effect of Fluid Overload Control Program on Knowledge and Behavior Among Caregivers of End-Stage Renal Disease Patients on Hemodialysis

Kanyanat Ummee[1], Kittipan Rerkkasem[2,3], Jukkrit Wungrath[1*]

[1]Faculty of Public Health, Chiang Mai University, Chiang Mai, Thailand, [2]Department of Surgery, Faculty of Medicine, Chiang Mai University, Chiang Mai, Thailand, [3]Research Institute of Health Science, Chiang Mai University, Chiang Mai, Thailand

Abstract

End-stage renal disease (ESRD) is a pressing health issue, and patients on hemodialysis frequently grapple with fluid overload. In Chiang Mai, Thailand, from September to November 2022, this study was conducted to assess the impact of an educational program on the knowledge and behavior of caregivers managing fluid overload in ESRD patients. Using a quasi-intervention design, participants were categorized into two groups: the intervention group, which underwent the educational intervention, and the control group, which continued with standard care. The educational content was grounded in existing studies and insights from healthcare professionals, caregivers, and patients. Post-intervention results revealed a significant enhancement in the knowledge and behavior of caregivers in the intervention group regarding fluid overload control compared to the control group (p-value<0.05). This study emphasizes the potential benefits of structured and evidence-based educational initiatives in equipping caregivers with the tools they need to better manage fluid balance, ultimately leading to improved patient outcomes.

Keywords: caregivers, end-stage renal disease, fluid overload, hemodialysis

Introduction

End-stage renal disease (ESRD) is a global public health concern affecting millions of people worldwide.[1] In Thailand, the prevalence of ESRD has risen significantly over the past five years (2018-2023).[2] According to the Thai Renal Registry, the number of ESRD patients in Thailand has increased from approximately 48,000 in 2018 to more than 58,000 in 2020.[3] In Chiang Mai, a major city in the Northern Thailand, the number of ESRD patients has also shown a steady increase, with over 3,000 patients currently receiving life-sustaining hemodialysis treatment.[4] The health status and quality of life of ESRD patients are often compromised due to the progressive nature of the disease and the burden of ongoing hemodialysis treatment.[5] Patients with ESRD frequently experience debilitating symptoms, such as fatigue, muscle cramps, and insomnia, significantly impacting their daily functioning and overall well-being.[6]

Furthermore, these patients often suffer from multiple comorbidities, such as cardiovascular disease, diabetes, and anemia, which exacerbate the challenges they face in managing their health.[7] Hemodialysis removes waste products from the blood and helps manage fluid balance, but it also presents challenges, such as fluid overload, which is a common complication among ESRD patients.[8] Fluid overload in ESRD patients can have severe consequences on their health and overall well-being. The impacts and effects of fluid overload include increased blood pressure, additional strain on the heart, and exacerbation of existing cardiovascular conditions.[9-11] This can lead to life-threatening complications, such as congestive heart failure, pulmonary edema, and even death.[12,13]

One of the critical factors contributing to fluid overload in ESRD patients is the lack of suitable knowledge and practice among caregivers who are responsible for the care and treatment of these patients.[14,15] Many caregivers, often family members, lack the necessary understanding of the complexities of ESRD and the skills to effectively manage fluid balance in patients undergoing hemodialysis.[16] As a result, patients may experience fluid overload, leading to further health complications and reduced quality of life.[17,18]

Despite several attempts to improve the knowledge and practice of caregivers of ESRD patients, previous studies and interventions focusing on fluid overload

Correspondence*: Jukkrit Wungrath. Faculty of Public Health, Chiang Mai University, Chiang Mai, Thailand 50200, Email: jukkrit.w@cmu.ac.th, Phone: +66 81-595-9638*

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control have been limited and insufficient. This gap in the literature highlights the need for a more comprehensive and targeted approach to address the specific needs of caregivers in managing fluid balance in ESRD patients.[19,20] This study aimed to bridge this gap by developing and implementing a tailored education and self-management program for caregivers of ESRD patients undergoing hemodialysis in Thailand. This program will be designed based on the existing literature's findings and input from healthcare professionals, caregivers, and patients to ensure that it effectively addresses the unique challenges faced by this population.[21] Equipping caregivers to better control fluid balance can significantly improve patient health outcomes and optimize resource utilization in public healthcare. Learnings from this comprehensive caregiver education program could inform future public health policies and practices globally.[22]

Furthermore, this study would employ a rigorous evaluation framework to assess the impact of the intervention on caregivers' knowledge and practice, as well as patient health outcomes related to fluid overload control. This will help determine the program's effectiveness and provide valuable insights for future studies and practice in this area.[23,24] Ultimately, this should result in improved patient health, reduced risk of fluid overload, and an enhanced quality of life for both patients and caregivers.[25] Moreover, the study would investigate the effectiveness of the adapted fluid overload control program by evaluating the changes in caregivers' knowledge, attitudes, and practices related to ESRD and fluid management.[21]

Additionally, this study would assess the program's impact on patient health outcomes, such as blood pressure, interdialytic weight gain, and hospitalization rates related to fluid overload complications.[26,27] This study offered a tailored educational program for caregivers of ESRD patients, aiming to enhance their skills and knowledge. By doing so, it not only promises improved health outcomes for patients on hemodialysis but also suggests a model that could be replicated globally, potentially leading to significant reductions in healthcare costs and elevating the quality of care for ESRD patients worldwide.

Method

This cross-sectional study was conducted at Hospital A in Chiang Mai Province, Thailand. The sample size was calculated using G*Power software, a free program, considering an alpha level of 0.05, a power of 0.80, and a medium effect size. The calculated sample size was 100 participants, equally divided into the intervention group (n = 50) and the control group (n = 50). Inclusion criteria were patients aged 18 years or older diagnosed with ESRD and receiving hemodialysis for at least three months prior to participating in the study. Exclusion criteria included patients with severe cognitive impairment, active malignancy, or requiring palliative care.

Purposive sampling was used to recruit caregivers meeting inclusion criteria. The authors approached eligible caregivers at dialysis centers and enrolled interested participants who consented. Once the target sample size was reached, participants were matched into pairs based on key characteristics. The matched sample was then randomly divided into intervention and control groups. Simple randomization was then used to allocate each pair to the intervention or control group. Matched pairs were assigned random numbers using computer software. Based on the numbers, one participant from each pair was allocated to the intervention and the other to the control groups. This random allocation after matching ensured comparable intervention and control groups, reducing selection bias.

The study tools used in the study were divided into three parts, which were developed based on a comprehensive literature review and expert consultations, including the authors team's physicians.

Part 1: Demographic data collection involved gathering information on the participants' age, sex, education level, occupation, duration of hemodialysis, and any comorbidities. Part 2: The Fluid Overload Control Knowledge Test was a 21 true-false multiple-choice questions test that assessed the participants' understanding of fluid overload control for caregivers of ESRD patients on hemodialysis. This test was developed by the authors based on the literature review. Part 3: The Fluid Overload Control Behavior Questionnaire was developed following the literature review. It contained 22 items, and a 5-point Likert scale was used to evaluate participants' fluid overload control habits and adherence to recommended practices. The scale ranged from "Never" to "Always," and participants rated their agreement with each statement or indicated the frequency of behaviors. This approach comprehensively captured participants' fluid overload control behaviors and adherence.

The Content Validity Index values for both research tools were found to be above the acceptable threshold of 0.86. Additionally, Cronbach's alpha coefficients for the fluid overload control knowledge test and fluid overload control behavior questionnaire were 0.803 and 0.807, respectively, demonstrating internal reliability.

The intervention group received a six-week education program through the Line application and telephone consultations from September to November 2022, while the control group received no intervention. Control participants were requested not to share study information, and authors team only interacted with the intervention group. Analyses comparing baseline character-

istics throughout the six-week study duration identified any contamination across groups. Communication via private Line groups and calls prevented sharing the educational intervention with controls. With measures including separate recruitment, limited interactions, supervised interventions, and baseline comparison, the study effectively prevented contamination of the control group.

The six-week intervention program for the intervention group combined on-site health education and telephone consultations to provide education, address challenges, and offer solutions to help participants effectively manage fluid overload.

Week 1 (26-30 September 2022): This week aimed to help participants identify unhealthy behaviors and set goals for changing them. Topics included identifying behavior triggers, developing action plans, and practicing self-monitoring. Week 2 (3-7 October 2022): This week focused on enhancing knowledge and self-awareness about controlling fluid excess. Topics covered the importance of controlling fluid intake, signs of excess fluid, and strategies for managing intake effectively.

Week 3 (10-14 October 2022): This week focused on experience sharing between caregivers and patients in managing excess fluid. Topics facilitated knowledge sharing and problem-solving related to the challenges faced in managing fluid, effective communication strategies, and ways caregivers can support patients. Week 4 (17-21 October 2022): This week reviewed knowledge on controlling excess fluid and focused on motivating and building confidence in practicing the skills learned. Topics reinforced previous knowledge and encouraged practicing fluid management techniques.

The telephone consultations were conducted by a qualified researcher using the "Brief Intervention Advice" technique during Week 5 (24-28 October 2022). The focus was on advising caregivers to increase their knowledge and skills in helping patients manage their fluid overload condition. Each consultation lasted approximately 5-10 minutes. Week 6 (31 October 2022) was a review of all the knowledge that had been taught, and a post-test was conducted.

During the 6-week study period, no specific intervention was given to the control group. Instead, they continued to receive regular care and followed standard fluid overload control recommendations from healthcare providers.

The data collected were analyzed using SPSS software (IBM Corp. 2021. IBM SPSS Statistics for Windows, Version 29.0). Descriptive statistics summarized baseline characteristics. In contrast, inferential statistics, including paired t-tests and independent t-tests, compared caregivers' knowledge and behavior regarding fluid overload within and between groups. Statistical significance was set at p-value<0.05.

Results

Demographic data analysis (Table 1) indicated that

Table 1. The Characteristics of Samples

Variable	Category	Intervention Group (n = 50)		Control Group (n = 50)		p-value
		n	%	n	%	
Sex	Male	19	38	12	24	0.13[a]
	Female	31	62	38	76	
Age (years)	<41	11	22	11	22	
	41-50	11	22	11	22	
	51-60	13	26	15	30	0.98[b]
	61-70	12	24	11	22	
	71-80	3	6	2	4	
Marital status	Single	13	26	11	22	
	Married	37	74	30	60	0.67[b]
	Divorced/Separated	0	0	9	18	
Education	Primary school	19	38	13	40.6	
	High school	19	38	19	47.1	0.64[b]
	Vocational/University	12	24	18	60	
Occupation	Employed	13	26	23	46	0.85[b]
	Unemployed	37	74	27	54	
Duration of hemodialysis (years)	<3	6	12	8	16	
	3-5	11	22	9	18	0.30[b]
	>5	33	66	33	66	
Any comorbidities*	Diabetes	25	50	23	46	
	Hypertension	43	86	40	80	0.11[b]
	Other	6	12	12	24	

Notes: [a] = Fisher's exact test (p-value<0.05), [b] = Chi-square test (p-value>0.05), *The respondent can choose to answer more than one disease that they have, so the total can add up to more than 50.

Table 2. Effectiveness of Fluid Overload Control Program on the Fluid Overload Control Knowledge Among Caregivers of End-Stage Renal Disease Patients on Hemodialysis

Fluid Overload Control Knowledge	Intervention Group		Control Group		p-value[a]
	Mean	Standard Deviation	Mean	Standard Deviation	
Before	14.82	1.64	14.36	2.02	0.21
After	17.80	2.79	15.10	2.52	p-value<0.05
p-value[b]	p-value<0.05				

Notes: [a] = Independent t-test, [b] = Paired t-test

Table 3. Effectiveness of Fluid Overload Control Program on the Fluid Overload Control Knowledge Among Caregivers of End-Stage Renal Disease Patients on Hemodialysis

Fluid Overload Control Behavior	Intervention Group		Control Group		p-value[a]
	Mean	Standard Deviation	Mean	Standard Deviation	
Before	4.11	0.72	3.95	0.62	0.25
After	4.54	0.37	4.15	0.58	p-value<0.05
p-value[b]	p-value<0.05				

Notes: [a] = Independent t-test, [b] = Paired t-test

the control and intervention groups had similar attributes. The control group comprised 12 men (24.0%) and 19 women (38.0%), with an average age of 2.64+1.17 years, while the intervention group included 19 men (38.0%) and 31 women (62.0%) with an average age of 2.70+1.23 years. The main causes of ESRD in both groups were diabetes (control: 46.0%; intervention: 50.0%) and hypertension (control: 80.0%; intervention: 86.0%). Both groups had comparable durations of hemodialysis treatment (control: 3.06±1.34 years; intervention: 3.36±1.42 years).

Mean pre-test and post-test scores to evaluate fluid overload control for the intervention group were 14.82 (SD = 1.64) and 17.80 (SD = 2.79), respectively, with the post-test average score significantly higher than the pre-test average score (p-value<0.05). Post-test mean scores for fluid overload control in the intervention and control groups were 17.80 (SD = 2.79) and 15.10 (SD = 2.52), respectively. The average fluid overload control knowledge score in the intervention group was significantly higher than in the control group (p-value<0.05), as shown in Table 2.

Mean pre- and post-test scores of fluid overload control behavior in the intervention group were 4.11 (SD = 0.72) and 4.54 (SD = 0.37), respectively, with the post-test average score significantly higher than the pre-test average score (p-value<0.05). Post-test mean scores for fluid overload control behavior in the intervention and control groups were 4.54 (SD = 0.37) and 4.15 (SD = 0.58), respectively, with average fluid overload control behavior score in the intervention group significantly higher than in the control group (p-value<0.05), as shown in Table 3.

Discussion

Results demonstrated significant improvements in fluid overload control knowledge in the intervention group after the intervention, consistent with related up-to-date field studies. Educational interventions are crucial to enhance knowledge and self-management skills for patients with chronic conditions such as heart failure or kidney disease. Previous studies showed that targeted educational programs led to better patient self-care behaviors and improved health outcomes.[28] McNaughton, *et al.*, found that a nurse-led education and support intervention significantly improved the self-care behaviors of patients with heart failure by focusing on fluid management, medication adherence, and symptom recognition.[29]

Similarly, Sbolli, *et al.*, demonstrated that tailored educational interventions that included individualized fluid management plans led to significant improvements in self-care behaviors and reduced hospital readmissions related to fluid overload.[30] Peng, *et al.*, conducted a systematic review and concluded that educational interventions, including fluid management education, improved self-management, reduced hospitalizations, and improved clinical outcomes for patients with chronic kidney disease.[31] This result was supported by the findings of a randomized controlled trial which found that a struc-

tured education program on fluid control inheart failure patients led to better adherence to fluid restrictions and improved fluid overload control knowledge.[32]

A previous study demonstrated that a web-based self-management program that included fluid control education improved knowledge, self-management skills, and clinical outcomes for patients with chronic kidney disease.[33] Post-test scores in the intervention group were significantly higher than in the control group, aligning with the consensus that well-designed interventions led to meaningful improvements in knowledge and self-management skills. These related studies reinforced the importance of implementing evidence-based educational interventions in clinical practices to help patients better understand and manage their health conditions, ultimately leading to improved health outcomes and quality of life.[34]

This study's findings aligned with a previous study indicating that comprehensively tailored educational intervention significantly improved caregivers' knowledge and practices related to fluid overload management.[34] A multi-modal delivery workshop combining take-home materials, Line group sharing, and telephone consultations facilitated knowledge acquisition and behavioral change by integrating interactive learning with ongoing support, with positive effects stemming from enhanced perceived self-efficacy, improved observational learning, and increased motivation through the intervention.[35]

Significant improvements in fluid overload control behavior were recorded in the intervention group, further emphasizing educational interventions' critical role in enhancing self-management skills and promoting better health behaviors. This is especially important for patients with chronic conditions such as heart failure or kidney disease, where effective fluid overload control is essential.[35] Several related studies supported these findings and reinforced the positive impact of educational interventions on fluid overload control behavior.[33,35] A tailored, self-management intervention for heart failure patients by Ha Dinh, *et al.*, demonstrated significant improvements in self-care behaviors, including fluid overload control.[36] The intervention was designed to address individual patient needs and involved teaching the patients to recognize and respond to changes in their symptoms. Dierckx, *et al.*, assessed the effects of a telephone-based self-management support program for patients with heart failure.[37] Their intervention included education on fluid management, with results leading to improved self-care behaviors and decreased hospital readmissions.

Another previous study investigated the effects of individualized educational intervention on self-management for patients with chronic kidney disease.[38] The intervention included fluid management, and results showed improved self-care behaviors, better fluid control, and reduced complications related to fluid overload. A randomized controlled trial by Huang, *et al.*, evaluated the impact of a nurse-led patient education program on self-care behaviors in heart failure patients.[39] This intervention focused on fluid management, with results demonstrating improved adherence to fluid restrictions and reduced hospital readmissions. At the same time, a previous systematic review and meta-analysis investigated the effectiveness of self-management interventions in heart failure patients.[40] This review concluded that fluid management education interventions improved self-management, reduced hospitalizations, and improved clinical outcomes.[40]

The post-test scores of the intervention group were significantly higher than the control group, aligning with the general understanding that well-designed interventions improved self-management skills and health behaviors. These related study results further supported the importance of implementing evidence-based educational interventions in clinical practices to help patients better understand and manage their health conditions, ultimately leading to improved health outcomes and higher quality of life. The multi-modal educational program improved knowledge and practices by enhancing self-efficacy, observational learning, and motivation through reinforcement by overcoming barriers through greater nurse access, providing ongoing support, and imparting practical guidance focused on actionable skills.[35]

This study demonstrated how tailored, evidence-based educational interventions delivered through innovative modalities empowered patients and caregivers to improve self-management behaviors, highlighting the role of strategic public health education in driving positive behavior change for enhanced population health outcomes. This study's results supported the effectiveness of policies aimed at integrating similar educational interventions into standard ESRD care, increasing investments in scalable patient education programs, leveraging technology for accessible delivery, establishing standardized curriculums, fostering partnerships to disseminate education, strengthening the training of providers on teaching self-management skills, and reforming insurance policies to enable a greater focus on patient education.

This study has both strengths and limitations that must be considered when interpreting the results. The strengths included focusing on a clinically relevant issue of fluid overload control, which is critical when managing chronic conditions such as heart failure and kidney disease. By targeting this issue, this study contributed valuable insights into improving patient outcomes and quality of life. This study expanded existing study in this field and strengthened the argument for the effectiveness of educational interventions in improving fluid overload

control knowledge and behavior among patients with chronic conditions.

However, some study limitations should also be noted. First, the participants might not represent the broader patient population with chronic conditions, affecting the results' generalizability. Second, this study only focused on short-term outcomes, with long-term results possibly providing a more comprehensive understanding of intervention effectiveness. Last, this single-center study did not account for variability in patient populations, practices, and resources, which would be better addressed through multi-center studies.

Conclusion

This study underscores the potential of tailored educational interventions to enhance the self-management capabilities of caregivers for ESRD patients on hemodialysis. Drawing parallels with existing literature, the study reaffirms the universal significance of such programs in chronic disease management. As the healthcare landscape evolves, integrating evidence-based educational strategies remains vital to ensuring optimal patient outcomes and quality of life. While promising, the findings also highlight the need for broader, multi-center study to further validate and expand upon these insights, ensuring a holistic understanding of the intervention's long-term efficacy and applicability.

Abbreviations

ESRD: End-stage Renal Disease.

Ethics Approval and Consent to Participate

The Ethics Research Committee of the Faculty of Medicine, Chiang Mai University, approved this study (approval code: SUR-2563-07657).

Competing Interest

The authors declared no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Availability of Data and Materials

Data used in this study is available from the corresponding author upon reasonable request.

Authors' Contribution

KU and JW were responsible for conceptualization and methodology. KU collected data and performed an investigation. JW wrote the original draft. JW and KR critically reviewed the manuscript. JW supervised the study. All authors read and approved the final manuscript.

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Social Media Use Behavior and Social Media Disorder Among Faculty of Public Health Students During the COVID-19 Pandemic

Tiara Amelia*, Ulfi Hida Zainita, Evi Martha

Department of Health Education and Behavioral Science, Faculty of Public Health, Universitas Indonesia, Depok, Indonesia

Abstract

Excessive use of social media can lead to vulnerability to social media disorder, which is significantly related to the trend of mental health problems among college students. This study aimed to assess the prevalence of social media disorder among college students and to determine the relationship between the number of social media accounts, the total duration of social media use, and social media disorder. This cross-sectional study collected data through an online survey of 201 college students from the class of 2021 in the Faculty of Public Health, Universitas Indonesia. This study used the Social Media Disorder scale and univariate and bivariate analysis to analyze the data. The prevalence of social media disorder was 23.9%; 93% of students were classified as high-duration social media users, and 58.2% had more than 10 accounts. Statistically, there was a significant relationship between the number of accounts (p-value = 0.045) and social media disorder. However, there was no significant relationship between the duration of social media use and social media disorder (p-value = 0.560). As a suggestion, the self-regulation factor must be considered an independent variable in predicting social media disorder among college students.

Keywords: college student, COVID-19, mental health, social media, social media disorder

Introduction

Social media users in Indonesia in January 2021 reached 170 million (62%) out of a total population of 274.9 million.[1] In Indonesia, college students are the group with the highest penetration of social media users.[2] The GlobalWebIndex report shows that Gen Z (e.g., the generation born between 1997 and 2004), including college students, mainly use social media for entertainment.[2] As social media use increases among college students, digital well-being and mental health have become important issues since 2019.[2]

In the last five years, between 2017 and 2022, which includes the COVID-19 pandemic, various studies worldwide have shown that social media disorder (SMD) is significantly related to the trend of mental health problems among college students.[3-9] Excessive use of social media may lead to SMD.[10] The negative impacts of SMD that may occur among emerging adults are decreased mood, decreased life satisfaction, feelings of loneliness, decreased quality of life, reduced concentration, cyberbullying, decreased sleep quality, anxiety disorders, and increased fear of missing out (FoMO).[3-9]

A study by van den Eijnden, *et al*., explains that there is no official definition of SMD because most previous studies have examined the disorder based on social media platforms and have not used a common term.[12] However, they concluded that SMD is present if at least five of the nine criteria for interference (preoccupation, tolerance, withdrawal, persistence, displacement, problem, deception, escape, and conflict) in individuals are found in the past year.[12] These criteria refer to Internet gaming disorder, which is part of the Internet addiction construct officially recognized in the Diagnostic and Statistical Manual of Mental Disorders Fifth Edition (DSM-V).[10]

College students are the largest users of social media and are at risk of experiencing SMD. They are motivated to use social media to interact, be entertained, and seek information.[11] The GlobalWebIndex report shows that since the COVID-19 pandemic, college students' main activity at home is using social media (52%), and the average use per day was 2 hours 41 minutes.[2] Moreover, the average number of social media accounts per person in Indonesia was 10.5, which was higher than the Asia Pacific overall, with 9.3 accounts per person.[2]

Correspondence*: *Tiara Amelia, Department of Health Education and Behavioral Science, Building D 1st Floor, Faculty of Public Health, Universitas Indonesia, Kampus Baru UI Depok, Depok City 16424, Indonesia, E-mail: tiara.a@ui.ac.id, Phone: +62 821-1087-9442*

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However, there are few studies on SMD in Indonesia. Some studies have explored Internet addiction, but not SMD specifically. The Faculty of Public Health Universitas Indonesia (FPH UI) students took distance learning in March 2020 because of the COVID-19 pandemic. This condition increased students' intensity of social media use, making them vulnerable to SMD. Therefore, it is necessary to investigate the SMD situation at the FPH UI to determine the magnitude of the problem and the preventive measures that need to be considered. The faculty concerns on about public health issues, including mental health, and also is responsible for creating an academic environment conducive to mental health, even in distance learning. This study, therefore, aimed to assess social media use behavior, the prevalence of SMD, and determine the relationship between the number of social media accounts and duration of social media use and SMD among students.

Method

The conceptual framework of this study is visualized in Figure 1. The independent variables were the respondents' characteristics, motivation to use social media, duration of social media use, and the number of active social media accounts. The dependent variable was SMD. This study used a cross-sectional design with a quantitative approach. The purpose of using a cross-sectional design with an online survey in this study was to assess the prevalence of the respondents' characteristics, SMD, and motivations for using social media with univariate analysis and to determine the relationship between the number of social media accounts and the duration of social media use and SMD. Bivariate analysis was carried out with the Pearson correlation and a Chi-square test to determine the relationship between the duration of social media use and the number of accounts with SMD in students.

The samples measured in this study used the formula of hypothesis tests for two population proportions, and the minimal sample was 118 students.[13] The sampling technique used was non-probability purposive sampling. The sample population was the class of 2021 of FPH UI undergraduate students. A total of 201 respondents completed the online survey. Data was collected by distributing the online questionnaire via the WhatsApp and Line platforms using a self-administered method in September 2021.

The instrument used to measure SMD was the Social Media Disorder Scale. The SMD Scale has nine questions, allowing two answers: yes (1) and no (0). If the score was ≥5, it was categorized as SMD.[10] This study adopted the SMD Scale instrument, which was translated into the Indonesian language and tested for validity and reliability by Dewi and Lestari.[14] Dewi and Lestari conducted a validity and reliability test for the Indonesian version of the SMD instrument with 207 adolescents in the Special Capital Region of Jakarta, Indonesia, resulting in a Cronbach's alpha of 0.734 and an r-value of 0.513–0.614.[14] These results indicated a good validity and reliability of the Indonesian version of the SMD Scale.[14] Therefore, this study no longer conducted validity and reliability tests.

Results

As shown in Table 1, most respondents are female (92%) and aged 18 years (63.2%). The social media platforms all respondents used are WhatsApp, YouTube, and Line. Instagram and Twitter are also very popular (Table 2). Most respondents are high-duration users

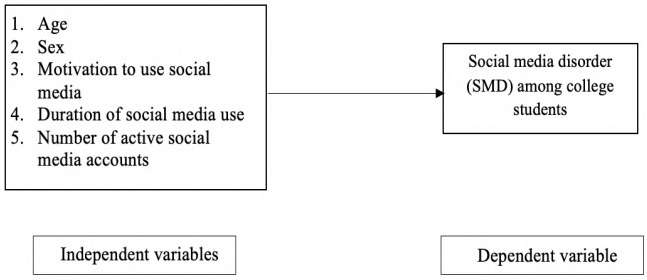

Figure 1. Conceptual Framework

Table 1. Respondent Characteristics (n = 201)

Variable	Category	n	%
Age	16	3	1.5
	17	31	15.4
	18	127	63.2
	19	38	18.9
	20	2	1
Sex	Female	185	92
	Male	16	8

Table 2. Social Media Use (n = 201)

Variable	Category	n	%
Social media platform	WhatsApp	201	100
	YouTube	201	100
	Line	201	100
	Facebook	114	56.7
	Instagram	192	95.5
	TikTok	102	50.7
	Twitter	168	83.6
Duration of social media use	Low (<3 hours per day)	14	7
	High (≥3 hours per day)	187	93
Number of active accounts	Low (<10)	84	41.8
	High (≥10)	117	58.2
Motivation to use social media	Interaction	66	32.8
	Entertainment	62	30.9
	Distance learning	40	19.9
	Seeking information	33	16.4

(93%) with a high number of active accounts (58.2%). Two primary motivations for using social media are interaction (32.8%) and entertainment (30.9%).

The prevalence of SMD in this study was measured with the SMD Scale. The SMD Scale has nine questions with two answers: yes (1) and no (0). Out of nine questions, if the yes answers were <5, it was categorized as not SMD, and if the yes answers were ≥5, it was categorized as SMD. The prevalence of SMD among the respondents was 23.9% (Table 3).

Table 4 shows that the number of students with SMD categorized as having a high duration of social media use was 24.1%. The relationship between the duration of social media use and SMD was analyzed using categorical data and a Chi-square test to determine the correlation. As shown in Table 4, there was no statistical relationship between the duration of social media use and SMD (p-value = 0.560).

The relationship between the number of active social media accounts and SMD was analyzed using numerical data and the Pearson correlation test to determine the correlation. Table 5 shows a statistically significant relationship between the number of active social media accounts and the SMD score (p-value = 0.045). Moreover, the relationship had moderate strength and a positive pattern (r-value = 0.141). This means the greater the number of active social media accounts, the higher the SMD score.

Discussion

The conceptual framework of this study is visualized in Figure 1. The independent variables are the respondents' characteristics, motivation to use social media, duration of social media use, and number of active social media accounts. The dependent variable is SMD. Based on the framework, the two hypotheses of this study are that (1) there is a relationship between the duration of social media use and SMD, and (2) there is a relationship between the number of social media accounts and SMD. However, duration and the number of social media accounts are not the only factors affecting SMD. Other variables affecting SMD include self-regulation, the need to belong, parental function, and so forth.[7-10] This study focused on the two variables of the duration of social media use and the number of social media accounts due to the follow-up of the two intervention studies with limited times.

Other than the duration of social media use and the number of social media accounts, this study also assessed motivation for using social media based on the uses and gratification theory. Motivation in this study was divided into four categories: distance learning, seeking information, entertainment, and interacting. Three of these four motivations were based on Karimi, *et al.*,'s study, that found three motivations for social media use in students based on the theory.[11] The first motivation is cognitive need, translated into seeking new information and learning new things in this study. The second and third motivations are affective and social needs, stated as seeking entertainment, such as listening to music, watching videos, and interacting with others. The fourth

Table 3. Prevalence of Social Media Disorder (n = 201)

Variable	Category	n	%
Social media disorder	Not social media disorder (score <5)	153	76.1
	Social media disorder (score >5)	48	23.9

Table 4. Relationship Between Duration of Social Media Use and Social Media Disorder

		Social Media Disorder						OR (95% CI)	p-value
		Not SMD		SMD		Total			
		n	%	n	%	n	%		
Duration of social media use	Low (<3 hours per day)	11	78.6	3	21.4	14	100	1.162 (0.310–4.349)	0.560
	High (≥3 hours per day)	142	75.9	45	24.1	187	100		

Notes: SMD = Social Media Disorder, OR = Odds Ratio, CI = Confidence Interval

Table 5. Relationship Between the Number of Active Social Media Accounts and Social Media Disorder

Variable	Mean (SD)	r	n	p-value
Number of active account	9.70 (3.854)	0.141	201	0.045
Social media disorder score	3.18 (1.862)			

Note: SD = Standard Deviation

motivation that was not included in Karimi, *et al.*,'s study was distance learning. This was explored because FPH UI has been running a distance learning since the COVID-19 pandemic in 2020.

The results showed that WhatsApp, YouTube, and Line were part of the respondents' daily lives. Hootsuite reported that WhatsApp and YouTube were Indonesia's most widely used social media and video streaming applications in January 2021, with an average monthly use of up to 30.8 and 25.9 hours, respectively.[1] Other platforms with a high percentage of users are Instagram and Twitter. The students used these three platforms (WhatsApp, YouTube, and Line) mostly for interactions related to distance learning, such as group assignments, communication, and coordination. Another motivation was seeking entertainment, most likely received from YouTube and Instagram. All these motivations led the students to become high-duration users (more than three hours per day), and they had many active accounts (≥10 accounts).[1] Moreover, the number of active accounts in this study was higher than the average number of active accounts per person in the Asia Pacific.[2]

The prevalence of SMD was 23.9% among the students in the FPH UI class of 2021. A previous study found that the prevalence of SMD among the students of the FPH UI class of 2018–2020 was 17.4%.[15] This implies that newer students had more SMD experience than older students. In this study, the data collection was carried out when the respondents had just started college. Hence, they had a break of about two months between senior high school graduation and college orientation. During the long break and in the pandemic era, they most likely spent most of their time at home. In addition, if they did not have good self-regulation and healthy relationships with their family, this situation could stimulate them to engage more with social media and become vulnerable to SMD.[16,17]

Students, as a category of emerging adults, are very susceptible to Internet addiction.[18] This is because, in young adulthood, the prefrontal and limbic cortex function is still not balanced, thus encouraging impulsive behavior.[18] In addition, students as young adults desire to learn to self-actualize, form self-identity, and have a perspective on the importance of peer relationships.[18]

This study found no statistical relationship between the duration of social media use and SMD (p-value = 0.560). Although the first hypothesis was that the more time spent on social media, the more vulnerable students would be to SMD, this finding and another study from the Netherlands disprove the hypothesis.[19] The study in the Netherlands was longitudinal and involved 2019 secondary school adolescents. The findings were that, over time, the intensity of social media use and mental health problems were not associated in any direction.[19] A study by Coyne, *et al.*, also showed that increased time spent on social media was not associated with increased mental health issues across development when examined at the individual level.[20]

On the other hand, this study found a statistically significant relationship between the number of active social media accounts and SMD. The relationship had moderate strength and a positive pattern. This means that the higher the number of social media accounts, the higher the SMD score. The active accounts used by respondents were divided between real and fake accounts. Real accounts showed people's true identities, while they used other identities in fake ones in social media interactions. Usually, they used this fake account to show their alter ego. The Merriam-Webster dictionary defines alter ego as a second self or a different version of oneself, such as the opposite side of a personality.[21] A study by Barry, *et al.*, supports these results, stating that the more accounts owned, the more mental health problems occur in adolescents.[22] Glazzard and Stones also showed that having multiple accounts on multiple social media platforms was associated with various mental health problems.[23]

Although the duration of social media use statistically had no relationship with SMD, studies from Indonesia and China state that it depends on the self-regulation of social media users, particularly among college students.[16,24] If college students have good self-regulation, they are able to control their social media behavior. This is because they are more aware that using social media too much leads to compulsiveness. A study by Balqis showed that emerging adults with high self-regulation are less likely to experience Instagram addiction.[16] These findings lead to the conclusion that the focus of SMD prevention should not be to cut off the duration as the main action but to enhance a self-regulation.

This study's strength was the addition of its findings to the limited existing studies related to SMD among adolescents. Since the greatest penetration of social media users is among adolescents in Indonesia,[2] there should be more studies on other public health problems caused by disorders or addiction behavior other than drug abuse. This study's limitations were the potential for biased respondents' answers due to the self-administered questionnaire, making it impossible to control the respondents' perceptions of questions, and the difficulty of ensuring their answers were true. The sampling method was purposive, so the results were not generalizable.

Conclusion

This study reveals that college students are experiencing SMD, and most have a high duration of social media use and an excessive number of active accounts. More-

over, the number of active accounts has a statistically significant relationship with SMD, while the duration of social media use other than not. Further study is encouraged to differentiate between the duration of social media use and SMD when studying the impact of social media on mental health. On the other hand, one variable that could be considered in developing measures to prevent SMD among college students is reducing the number of social media accounts. The more social media accounts, the more students are triggered to compulsively use social media compulsively, making them vulnerable to SMD.

Abbreviations

SMD: Social Media Disorder; FPH UI: Faculty of Public Health Universitas Indonesia.

Ethics Approval and Consent to Participate

This study obtained ethical approval from the Research and Community Engagement Ethical Committee of the Faculty of Public Health, Universitas Indonesia, No. Ket-190/UN2.F10.D11/PPM.00.02/2022. Informed consent from all the participants was obtained before the data collection, and the authors ensured their anonymity.

Competing Interest

The authors declare that there are no significant competing financial, professional, or personal interests that might have affected the performance or presentation of the work described in this manuscript.

Availability of Data and Materials

Data and materials are available from the corresponding authors.

Authors' Contribution

TA led and conceptualized this study, developed the methodology, wrote the original manuscript, and reviewed and edited the final manuscript. UHZ conducted the formal analysis, wrote the original manuscript, and reviewed and edited the final manuscript. EM checked the formal analysis and also reviewed and edited the final manuscript.

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System Safety Assessment of the Warehouse Operation Using Functional Resonance Analysis Method and Resilience Analysis Grid

Adithya Sudiarno[1,2*], Ahmad M D Ma'arij[1]

[1]Department of Industrial and Systems Engineering, Faculty of Industrial Technology and Systems Engineering, Sepuluh Nopember Institute of Technology, Surabaya, Indonesia, [2]Occupational Safety and Health Council, East Java Province, Surabaya, Indonesia

Abstract

This study applied the perspective of Safety-II using the Functional Resonance Analysis Method (FRAM) and the Resilience Analysis Grid (RAG) to analyze safety in warehouse operations from a system perspective. FRAM was used to emphasize what caused things to go right, with the findings highlighting higher performance and safety variability occurring in activities that require multiple individual or group efforts. RAG was used to assess the organization's potential to handle unexpected occurrences, identify the potential resilience of the warehouse in its daily activities, and evaluate the ability to maintain flow and worker safety based on four pillars of resilience. The assessment resulted in a value of 3.50 in the ability to respond, 2.84 in the ability to monitor, 3.88 in the ability to learn, and 3.21 in the ability to anticipate. Combining FRAM and RAG enhances the depth of a new perspective of safety analysis and addresses resilience factors in daily operations.

Keywords: Functional Resonance Analysis Method, Resilience Analysis Grid, resilience engineering, Safety-II, system safety

Introduction

Ensuring that tasks are completed with a minimal amount of problems is desirable in every line of work, particularly jobs that require repeated activities. Accidents or categorized hazards that may lead to risk are sometimes examined to avoid having a repeat of the same accident. This approach is known as Safety-I.[1] However, recent developments in the concept of safety have shifted how people view the work process. Rather than focusing on accidents, the approach aims to understand the right ways of accomplishing work. This new perspective has emerged as the concept of Safety-II.[1,2] The perspective of focusing on what makes things go right can improve our understanding of how a system works.[3] An advantage of using this new perspective is that the amount of work done right always outnumbers the amount of work done wrong (e.g., accidents).[4] Having a large amount of correctly done work to observe enables more activities to be reviewed, and these activities can serve as a basis for learning.

In the attempt to get things done correctly, having resilience in adjusting to the different working conditions on any given day is key to maintaining safe and desirable working conditions. According to Hollnagel, the causes of acceptable and unacceptable outcomes are similar.[1] Moreover, some effort should be made to keep performance at an acceptable outcome state, known as the concept of resilience.[5] Higher resilience means the increased likelihood for an activity to remain safe.6 Good resilience in an organization can help shape and improve its safety culture.[2,7] Ideally, the level of resilience is the same throughout the entire system. However, modern systems, often referred to as socio-technical systems, are highly complex and contain multiple interacting factors within the system, both socially and technically.[8] Hence, resilience can vary between these various factors.[8]

The Functional Resonance Analysis Method (FRAM) can be used to understand the work activities of a system by illustrating and analyzing the complex interaction of components in a socio-technical system.[8] This method has been researched and used for a wide variety of purposes, such as breaking down accidents that happened in the past,[9-12] analyzing day-to-day operation activities,[13-17] portraying possible undesirable outcomes as risk assessment,[18,19] and modeling a system before its implementation.[20,21] These previous uses of this method have

Correspondence:* *Adithya Sudiarno, Department of Industrial and Systems Engineering, Sepuluh Nopember Institute of Technology, Surabaya 60111, Indonesia, E-mail: adithya.sudiarno@gmail.com, Phone: +62 812-3012-388*

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shown that FRAM can illustrate a wide array of systems, clarify the interaction between system factors, and point out problems that might have to be addressed within a system.

Despite the wide potential for using FRAM, this method has scarcely been used to assess problems with supply chain systems.[22] Problems in any part of a supply chain system often occur with a relatively low impact but with high frequency,[23] particularly in day-to-day operations, such as warehouse activities. In the long term, this high frequency of problems potentially aggravates and lowers the overall ability of the warehouse to deliver products. FRAM can help analyze the system by pointing out where the performance variability in the system lies. Findings on performance variability can then help determine whether the system has the resilience to handle the constantly changing situations in the everyday work environment.[24]

The Resilience Analysis Grid (RAG) is used to measure the potential resilience capabilities of the system based on four pillars of resilience (respond, monitor, learn, and anticipate).[25,26] The RAG method has been used to measure potential resilience in the medical field,[27] air traffic management,[28] and heavy vehicle transport.[29] This study discussed the breakdown of the warehouse system as part of the supply chain using FRAM, the results of which could point out the function with the highest possible performance variability. Further analysis entailed the use of the RAG method to measure the potential resilience of the organization against variability. This study also exhibited the application of the perspective of Safety-II in the logistics industry, which has been rarely observed.

Method

This study was conducted from October to November 2021 in one of the Fast-Moving Consumer Goods (FMCG) distribution companies in Surabaya, Indonesia. First, three types of data gathering were conducted: direct observation, non-structured interviews, and structured questionnaires. FRAM was then used to model the flow of daily activities within the warehouse operation to find the possible aggregation of performance variability. This step resulted in a FRAM model that provided detailed information on the functions with high safety performance variability. A further analysis was conducted where RAG was used to measure the potential resilience level against the performance variability found in several functions based on the FRAM model. Findings were then mapped into a spider chart and interpreted and analyzed before the concluding remarks were given. Figure 1 exhibits the schematic structure of this study.

Data were collected in late October 2021. First, direct observation of the warehouse condition was conducted with the manager's permission, and any occurrences observed were noted. The purpose of the observation was to gain a better understanding of the process inside the warehouse. This included any step of the process according to six nodes in the tools and categorizing each process into connected nodes to represent the warehouse system.

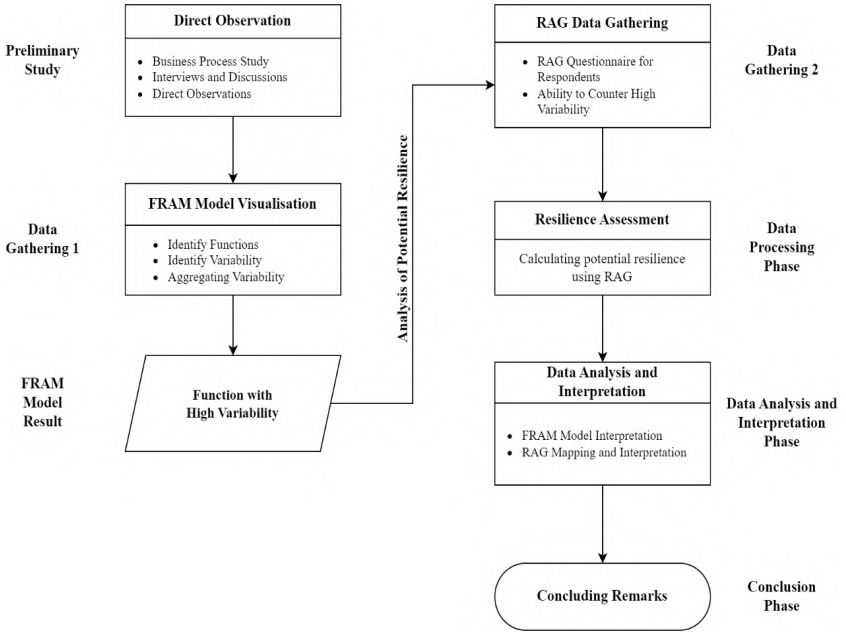

Figure 1. Structured Schematic of the Study

The observation began the moment the products arrived at the warehouse and continued until they were placed on the truck for delivery. Non-structured interviews accompanied the observation. The combination of observation and interviews helped to provide a more in-depth understanding of the ideal functioning within the system and facilitated the construction of the model. The collected data were analyzed using FRAM to visualize the overall activities inside the warehouse based on all the information derived from the observation and interviews. Each activity was analyzed into a function in the FRAM visualizer, and the factors affecting each function were described to identify the connection between the functions.

The critical functions that were deemed to contribute to system irregularities were analyzed with RAG to rate the potential resilience to deal with the constantly changing conditions. The questionnaire consisted of 20 question items, with 20 variables: the ability to respond (8), monitor (4), learn (5), and anticipate (3). These question items represented 20 variables chosen and suited to the warehousing activities. In total, 33 participants from the FMCG central warehouse completed the structured questionnaire. The participants ranged in age from 25 to 51 years, and the length of their work experience in the warehouse ranged from 3 to 31 years. The sampling was made possible by the manager, who provided access to the warehouse, and the willingness of operators and pickers/packers to participate during their scheduled work hours. The responses given by the participants were then calculated and mapped using a radar chart to represent the average score of each variable within each of the four abilities and the overall score of potential resilience.

Results

Functional Resonance Analysis Method Model Visualization

The FRAM model was created through four steps: identifying functions, identifying variability, aggregating variability, and model constructions. The steps and their results are described below.

a) Identifying Functions

The tasks related to the daily operation activities of the warehouse were observed, identified, and then put into functions in the model. Details of the observation activity have been described in the Method section. Observation included receiving products from manufacturers, loading the products into trucks for delivery, and handling returned items. The listed activities were classified into 14 foreground functions, 6 background functions, and 3 functions for completeness of the model. An overview of the functions is presented in Table 1. The classification was divided into three categories: 1) whether the activity changed the status of the input during the process (foreground functions), 2) the activity that did not change the status of the input (background functions), and 3) listed processes that needed to connect with other functions (function for completeness).

b) Identifying Variability

Several foreground functions had different inputs that needed to be coordinated to accomplish a successful operation. This was especially true for the functions that took longer to complete. Functions that were mostly run by humans were key as they entailed a higher potential for imprecise output variability. Human functions combined with organizational aspects could also influence variability as the interaction went further, leading to the aggregation of variability inside the system.

c) Aggregating Variability

Ideally, the aggregation of variability would be found in downstream activities because such activities are performed by humans. Moreover, these activities require a great deal of coordination and communication in order for the function to be performed seamlessly. Functions that usually take longer to finish, combined with the need for a large group, would result in wider variability and more aggregated variability, which would result in a step/function with the wave sign of resonance in the background of the function hexagon in the model.

d) Model Construction

The functions listed in Table 1 built into the model were color-coded to display the different function performers. Blue represented the unloading material handling team, green represented the picker/packer loading team, and red represented the returned items handling team. The complete visualized model can be seen in Figure 2, where aggregated performance variability was found in the functions of item placement on the rack, the picking of items, and the delivery process.

Resilience Analysis Grid Assessment Results

According to the model, a possible performance variability was detected in the functions carried out by the material handler and picker/packer in the warehouse. This made it appropriate to focus on the potential resilience of the material handler and picker/packer. RAG assessed the average score of each variable of the four abilities and the overall score regarding potential resilience.

a) Ability to Respond

This ability showed how well the organization responds to undesired or unusual occurrences. Eight variables were fitted to measure the ability to respond. The result was 3.09 in event list, 4.09 in background, 2.61 in threshold, 3.58 in response capability, 2.61 in speed, 3.55

Table 1. Overview of Functions in Warehouse Operations

Foreground Function	Background Function	Function for Completeness of Model
• Items input to the system • Rack placement labeling of item • Unloading item • Item placement to rack • Making goods pickup document • Allocating delivery order • Issuing dispatch report • Listing items in picking slip • Printing loading sheet • Delivery process • Item drop off at bad stock warehouse • Item repacking • Issue to the central warehouse • Item transfer • Returned items registered to the system	• Truck entering the loading dock • Checking of goods receipt • Item transfer from bin to bin • Register bin to bin • Items selection • Invoice deletion	• Warehouse system • Warehouse rack • Items burning

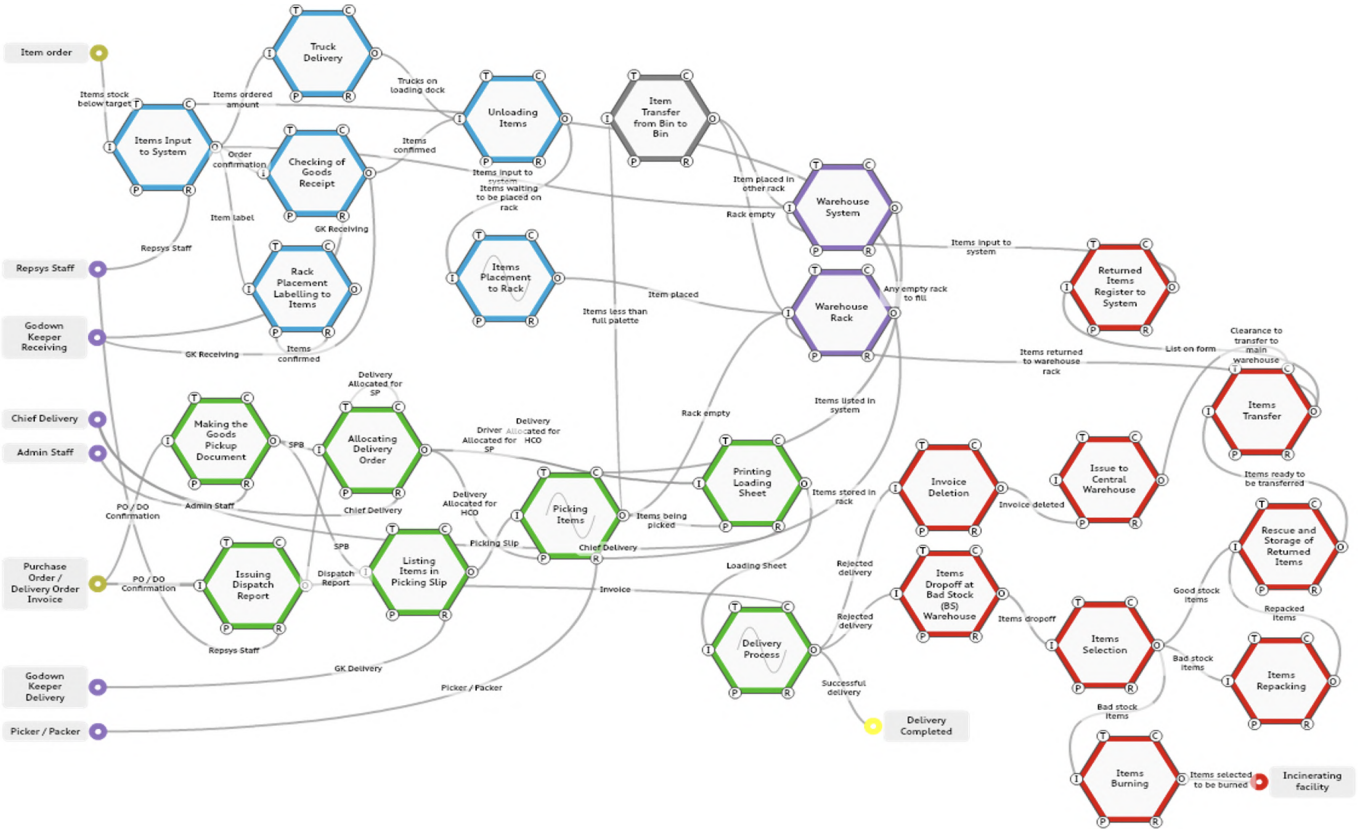

Figure 2. Functional Resonance Analysis Method Model Visualization of Warehouse Activity

in stop rule, 4.10 in duration, and 3.82 in relevance. The mapping of the average score of each variable is illustrated in Figure 3a.

b) Ability to Monitor

This ability showed how well the organization can spot the signs of any possible difficulties. Four variables were used to measure the ability to monitor. The result was 3.04 in the indicator list, 2.92 in measurement type, 2.84 in measurement frequency, and 2.54 in relevance. A mapping of the average score of each variable can be seen in Figure 3b. This result showed that while there were

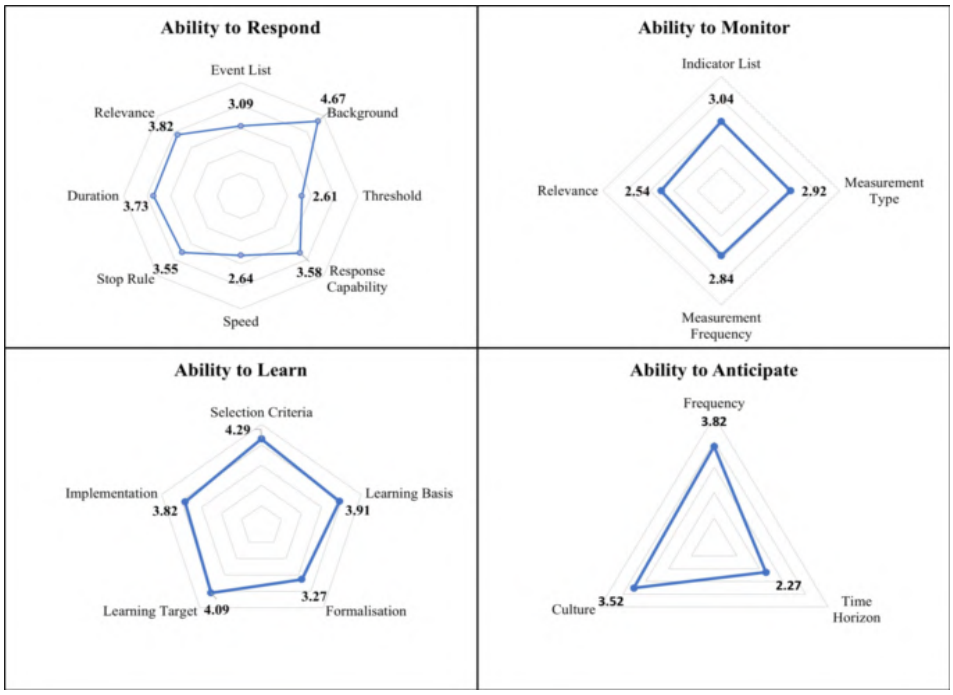

Figure 3. Mapping of the Average Score of Each Variable Regarding Resilience Ability; (3a) Ability to Respond; (3b) Ability to Monitor; (3c) Ability to Learn; and (3d) Ability to Anticipate

available measurement indicators to compare the usual capability with the increasing number of orders, the use of the indicator lists of performance was not perceived as optimal by the workers, resulting in the average value of the measurement type sub-variable. The measurement indicator was also used infrequently (only yearly monitoring), resulting in a low value of the frequency sub-variable. The performance indicator was also infrequently updated with the recent historical data of the total orders because the lists were only updated every 2-5 years and did not consider trends, seasonal demands, etc., resulting in a low relevance value sub-variable.

c) Ability to Learn

This ability showed how well the organization selects and learns from previous events and better understands how to succeed under various conditions. Five variables were used to measure the ability to learn. The result was 4.29 in selection criteria, 3.91 in learning basis, 3.27 in formalization, 4.09 in learning target, and 3.82 in implementation. A mapping of the average score of each variable can be seen in Figure 3c. The company had an excellent score in the ability to learn, with a value of 3.88. This means that in some cases, workers in the warehouse had a relatively good ability to learn from the previous adverse events, as evidenced in the selection criteria (4.29), indicating that almost all near misses, incidents, and accidents were investigated and managed. The score of the learning target (4.09) showed that any efforts at improvement based on the investigation of an accident were applied to a wide range of targets (e.g., all personnel inside the warehouse).

d) Ability to Anticipate

This ability showed how well the organization uses its knowledge to anticipate future difficulties and hence give better responses in the future. Three variables were considered suitable to measure the ability to anticipate. The result was 3.82 in frequency, 2.27 in time horizon, and 3.52 in culture. A mapping of the average score of each variable can be seen in Figure 3d. The score of the ability to anticipate (3.21) indicated that the workers believe that management could anticipate when the orders will increase regularly, despite the short time horizon of anticipating a surge of orders (e.g., one week, one month, three months). This means that the frequency of anticipating orders was still not in line with the expected time horizon, with the frequency of increasing effort being done more often. This was caused by a disparity between a possible increase in orders and the anticipative action to counter it. The workers and the delivery dispatch were often forced to adjust the delivery to be earlier than

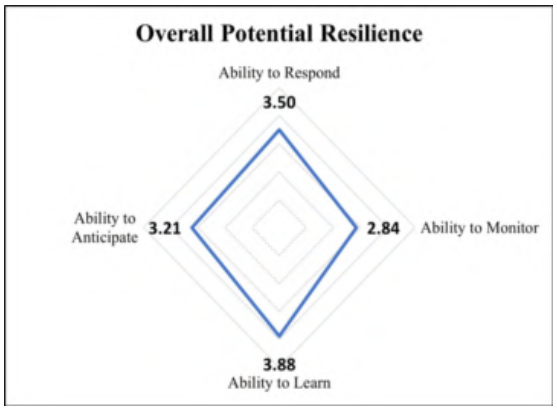

Figure 4. Average Score of the Four Abilities of Potential Resilience

planned. This means that the organization was likely to respond rather than anticipate.

e) Overall Potential Resilience

The final step was to average all values of the variables that formed the ability into a single radar chart containing the average value of each of the four abilities. The final chart results were 3.50 in the ability to respond, 2.84 in the ability to monitor, 3.88 in the ability to learn, and 3.21 in the ability to anticipate. Figure 4 illustrates the result.

Discussion

Functional Resonance Analysis Method Model Result

Performance variability was found in one or many functions that could lead to the bottlenecking of the orders and thus delay delivery. Performance variability was more aggravated in three functions (item placement to the rack, picking items, and delivery process). The effect of bottlenecking could be amplified due to the instability of the work needed in coupling activities.[14] A similar result could also be found in the daily activities of warehouse operations. Occasionally, an escalation of orders would occur at a particular time. The increasing number of products being sent to the warehouses and the number of items loaded into trucks also delayed the time for the delivery process to be finished. This meant that the cycles in the system intensified due to more frequent cycles being sequenced together, possibly simultaneously, with the performance variability cumulated from each cycle, which would amplify the performance variability.[12]

A higher effort would be needed by the material handler and picker/packer of the warehouse. If the effort remains unchanged, the palettes of products will pile up at certain crucial places (e.g., the receiving gate or loading dock), hindering the product loading/unloading process. Hence, a potential hazard is created in which unsafe conditions could lead to unsafe action and the possibility of misses, incidents, or even accidents.[9] This potential hazard was applied to the material handler and picker/packer inside the warehouse.

In the delivery process, performance variability was found due to the diverse number of orders during the day, added to the postponement from the preceding day. The urgent delivery also aggravated this situation, as resources were allocated to prioritize these orders. This meant that normal delivery orders usually scheduled regularly would be postponed until the next one or after. This postponement intensified at times when the number of orders increased. This showed that a great deal of effort is required of the current resources to meet the escalated demands. Hence, it is important to understand the system and identify where humans are positioned as their role is key.[30]

It is worth noting that the FRAM method is proven to be beneficial in understanding the complexity of a system more deeply,[13] as there are one or more factors that might contribute directly or indirectly to the ability of performers to do their tasks. In the case of warehouse activity, its risk is aggregation from multiple low-risk events. However, any further analysis should be done to bolster the result of the analysis, as FRAM is meant to be used as the initial process of understanding complexity and pointing out the tasks where resilience is needed,[9] due to the large performance variability that can affect not only the tangible but also the intangible result.[10]

Resilience Analysis Grid Assessment Result

Measuring potential resilience shows the level of knowledge, competence, focus of resources, and time of the organization.[31] Dynamic developments in the environment force the system to adapt or respond based on the organization's resources and capabilities.[32] The ability to respond is an important aspect and is the first pillar of resilience for the organization to deal with undesirable or unanticipated events.[33] In this study, the average score of the potential ability to respond was 3.50, which indicated that the organization already had several ways to deal with certain situations. As an organization increases its ability to manage more situations, the likelihood of the organization succeeding in unexpected outcomes increases. Therefore, fewer things would go wrong, which would improve the safety of the whole system at an organizational level.

The ability to monitor showed a value of 2.84, which was relatively low, particularly in 3 out of 4 variables. The lack of the ability to monitor prevents the maximization of the potential ability to learn. On the other hand, the workers showed that they were able to learn from previous events, resulting in the workers being more ex-

perienced in performing the activity. While this was a good sign, it would be beneficial to provide additional training to workers to improve their knowledge, particularly in monitoring potential near-misses or accidents.[34]

Potential resilience measures an organization's ability to recover from both usual and unusual events that may occur during working hours.[35,36] If any undesirable outcome occurs, it does not effectively mean that the system lacks safety.[5] Undesirable outcomes test the ability of the organization to rebound and maintain the natural flow of the work. While it does not happen all the time, the effort needed for an organization to stay "normal" may differ from time to time in the repetition of the same sequence of activities.

It is also important to note that despite the need for various types of organizations to respond well as the initial step towards resilience, the path towards resilience may also differ from industry to industry. For example, the supply chain industry needs to develop the ability to anticipate rather than the ability to monitor or learn. In contrast, high-risk industries (chemical, oil, etc.) need to develop the ability to monitor rather than the ability to learn or anticipate.[37]

While resilience and safety seem to be two distinct aspects, they always coexist in the effort to achieve better operational excellence. Resilience could be considered as the shape of control for the system to keep delivering safe results,[3] as the greater the effort, the higher the likelihood of remaining in control of the system, regardless of both expected and unexpected outcomes, resulting in better safety enforcement, along with the goal of safety (freedom from unacceptable risk) that could be reached much easily.

Conclusion

This study shows the results of applying the FRAM in breaking down the complexity of a system where the interactions occurred between humans, machines, and groups. Possible performance and safety variabilities are found more often in activities requiring more than one person or a multiple group effort to finish a single task, resulting in a potential performance imbalance when unexpected events occur. Further assessment using RAG shows the ability of the organization to adjust its performance to counter unexpected occurrences. The warehouse shows a high ability to learn, but this is not maximized due to the relatively low ability to monitor. With the new perspective of Safety-II, both methods are used to analyze system safety, with FRAM pointing out safety performance variability and RAG measuring the ability to cope with the variability.

Abbreviations

FRAM: Functional Resonance Analysis Method; RAG: Resilience Analysis Grid; FMCG: Fast-Moving Consumer Goods.

Ethics Approval and Consent to Participate

FMCG warehouse workers were given consent to participate as respondents for the RAG analysis.

Competing Interest

The authors declare that they had no conflicting interest in this article.

Availability of Data and Materials

The data presented in this study are available and can be provided by the authors.

Authors' Contribution

AS contributed to conceptualization, research material selection, and manuscript review. AMDM contributed to manuscript writing, collecting data, data processing, final editing, and uncovering research material.

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Abdul Kadir
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