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Kesmas

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(National Public Health Journal)

Quarterly Journal

Invited Article:

Consumption of Sugar-Sweetened Beverages and Its Potential Health Implications in Indonesia (pp. 1-9)

Research Articles:

Increased Thyroid Hormone Levels in Pesticide Sprayer at Agricultural Area (pp. 10-16)

Body Image, Quality of Life and the Predicting Factors in Pregnant Women: A Cross-Sectional Study (pp. 17-24)

The Estimation of Excess Mortality during th COVID-19 Pandemic in Jakarta, Indonesia (pp. 25-31)

The Development of a Work Stress Model for Air Traffic Controllers in Indonesia (pp. 40-47)

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

I am thankful for Kesmas: Jurnal Kesehatan Masyarakat Nasional (National Public Health Journal) Volume 16-4 for the various topics in every article per one edition. Trapped in almost two years of the COVID-19 pandemic made us anxious and sometimes want to ignore the pandemic issue for a while. Reading the various articles in Volume 16-4 made me realize more; that the public health issue is not only the COVID-19 pandemic but also so many others like *Toxoplasma gondii* or HIV/AIDS. Even so, the articles about the COVID-19 pandemic in Volume 16-4 will become a reminder that the pandemic is not going to end soon. Please stay safe and sane wherever you are. **(Rakai, Jakarta)**

INFORMATION

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Kesmas: Jurnal Kesehatan Masyarakat Nasional (National Public Health Journal)

Consumption of Sugar-Sweetened Beverages and Its Potential Health Implications in Indonesia

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Abstract

The broad availability of sugar-sweetened beverages (SSBs) in the Indonesian market is increasing consumption. It, combined with escalating incidence and prevalence of diabetes and related non-communicable diseases (NCDs), and the ongoing debate on policies, has called for a comprehensive review as described in this study. Data was compiled from various sources but mainly gathered from the reported or published documents because of no direct access to the necessary data set. The lack of studies that assessed the direct relationship between SSB consumption and health outcomes in the Indonesian context also became a strong reason for the preparation of this review to highlight important points for further research, academic reviews, and debates on empiric policies to control sugar consumption at the population level. Sociocultural factors were an apparent and crucial determinant of the sweetness preferences of mainstream Indonesians. They were not capitalized in the available documents and should be embraced in future health promotional measures. Given the high contribution of carbohydrates and sugar to total energy intake in the Indonesian diet, it is pertinent to control the increasing trend of SSBs consumption through interventions on both the supply and demand sides.

Keywords: access to beverages, health outcomes, Indonesian consumption, sugar-sweetened beverages, sweetness preferences

Introduction

Of the several methods used to control the prevalence of noncommunicable diseases (NCDs) in Indonesia, limiting incredibly high sugar intake among the population—as indicated by the ubiquity of sugary foods and beverages on the market—is considered to be particularly essential. Beyond being easily accessible, these diverse products are offered at various price points, making them affordable for people of all socioeconomic classes. These items are sugar-sweetened beverages (SSBs), consumed both at and outside of mealtimes, with or without food.

Yet, up to now, the Indonesian Government has not implemented a significant policy to control sugar consumption, including SSB, as part of its efforts to control NCD. One argument is the lack of scientific studies or reviews as empirical evidence of the impact of sugar consumption on population health in the Indonesian context, as done in many other countries.[1] Understanding the issue of sugar consumption and its impact in this local context is critical considering the significance of various environmental factors on determining the diet of a given population, especially in Indonesia, which has very diverse tribes, races, and geographical conditions. In other words, multiple reports of the success of several countries' policies in controlling sugar consumption,[2-6] including SSB, can be a reference, could not be directly adopted, but still need to be studied and adapted to the Indonesian context for its implementation.

This paper aimed to review the following sequentially: (1) how habitual SSB intake among Indonesians could be shaped by its market accessibility and sociocultural preferences overall, (2) the substantial contribution of SSB consumption to daily sugar intake, and (3) concerns on limiting sugar intake as NCDs become a more serious national public health concern.

Method

The preparation of this review paper followed the logical steps applied by the World Health Organization (WHO) in developing a guideline.[7] After the authors

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agreed on the objectives and purposes of writing this review paper, a search of the literature and relevant data sources was carried out to be used as references. Out of many scientific studies on sugar-sweetened beverages (SSBs), the authors have focused on publications within the Indonesian contexts, except for the health-related outcomes of high SSB consumption. Due to the lack of publications related to SSB in the Indonesian context, the literature compilation process was carried out in two ways: using systematic search engines (ScienceDirect) and manual document selection based on expert judgment from the authors. The literature ranged from peer-reviewed journals, national survey reports, policy documents, and even some online articles, especially those related to the historical perspective on the sweetness preference of the Indonesian population.

Although the National Basic Health Research/*Riset Kesehatan Dasar* (Riskesdas) surveys include some indicators on SSB consumption and cardiometabolic syndrome (CMS), the authors did not have access to the raw data. Therefore, necessary analytical tests could not be performed using the data. Thus, based on the literature review, the present elaborations on the SSB market, its consumption pattern, and health consequences of high SSB consumption among mainstream Indonesians.

Results and Discussion

Sociocultural and Behavioral Factors and Sweetness Preferences among Mainstream Indonesians

The predisposition to sweetness is an innate preference that can be altered through repeated sensory exposure and familiarization to certain tastes and flavors as early as during the prenatal period.[8-10] Short- and long-term exposure to sweetness in food or drink, termed learned responses, can increase the inclination and stimulus threshold for sweetness.[11,12] Such responses typically originate from and form through repetitive exposure to foods prepared regularly at home, which are decided by family choices or parental preferences.[13-17] These selections can constitute a fusion of local food culture and what is accessible or available on the market.

The combination of innate and learned hedonic responses to sweetness, triggered by a complex neurobiological mechanism, is probably why most Indonesians favor sweet foods or beverages. These preferences can be traced back to the *cultuurstelsel* or cultivation system government policy in Indonesia under Dutch colonization.[18,19] The policy was defined by the enforcement of the planting of export crops such as sugarcane (processed into cane sugar for export). Hundreds of sugar factories operated out of East and Central Java (Figure 1). Until the onset of the Great Depression in 1930, East Java was the center of the second-largest sugar industry in the world.[20]

During this era, the extreme conversion of 70% of Indonesia's rice fields into sugarcane plantations led to a sharp decline in rice production. With rice being a staple food, this caused mass hunger among approximately 80.6% of Indonesians, who were Java residents according to census data from 1905.[21-23] Sugarcane juice was

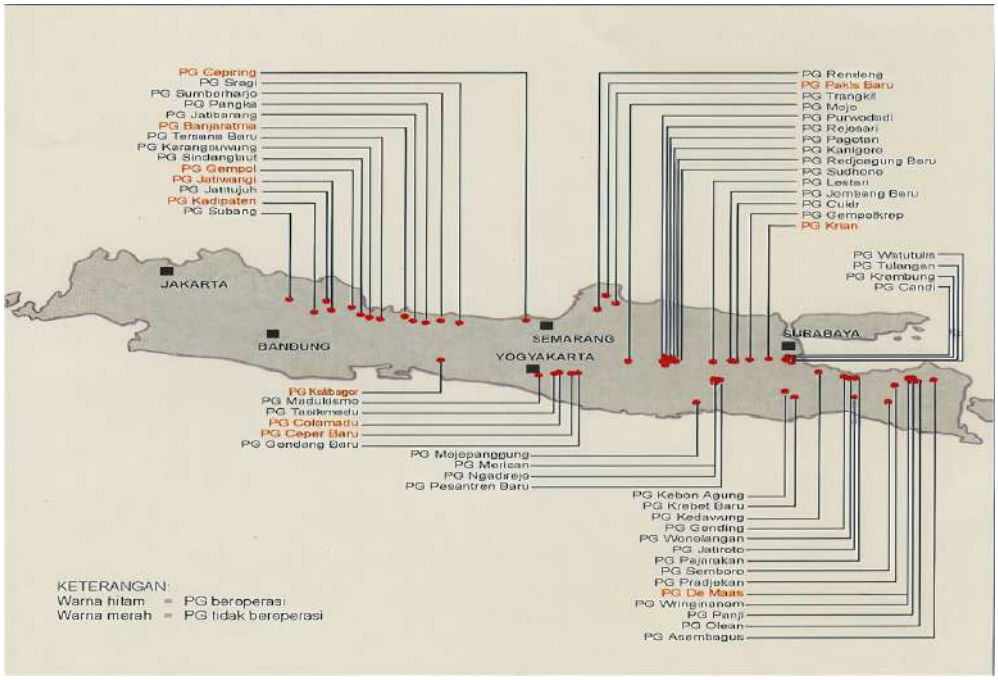


Figure 1. Sugar Factories in Java Island,[24]

increasingly used for cooking to compensate for the carbohydrate intake that would have ordinarily come from rice consumption. In the long term, preference for sweetness in food and drink was absorbed into local food culture and dietary habits. Following domestic migration, which explained the 11.9% reduction (80.6% to 68.7%) in Indonesians residing in Java between 1905 and 1930, these changes spread to other islands in the country.[22,23]

The Sugar-Sweetened Beverages Market and Patterns of Sugar-Sweetened Beverages Consumption among Mainstream Indonesians

According to 2019 study conducted by the Monell Chemical Senses Center in the United States, which involved a synthesis of 400,000 customer reviews, food products commercially available today are more on the sweet side or even considered overly sweet, and this is regarded as a global phenomenon.[24] Specifically, SSBs have become increasingly variegated after 2000 and accessible over the years. Before 2000, SSBs comprised a limited selection of soft drinks, sweetened teas, juices or juice-based drinks, and sweetened milk and fermented milk beverages. Today, consumers can also choose from sweetened coffee, flavored water, energy drinks, honey drinks, bubble tea, and powdered drinks. Each type varies in brand, volume, sugar content, price, packaging, and targeted customer groups.

Within the country, SSBs are produced by medium and large corporations and small microenterprises that have absorbed many workers.[25] The inclusion of more than 60% of street vendors into retail businesses has made SSBs highly accessible to various classes of customers, accounting for taste preference, purchasing power, and even lifestyle. Thus, it is unsurprising that the recent data from the Liquid Intake over 7-Days (Liq.In7) surveys, which were conducted across Europe, South America, and Asia,[26] showed that SSBs constitute the third-largest source of Indonesians' liquid consumption (227 mL/day, approximately 8%) after water and hot beverages (2,164 and 263 mL/day, or approximately 80% and 10%, respectively). Herein, SSBs refer to both factory-made products and homemade beverages such as coffee or tea, to which sugar is typically added. From 22 samples of SSBs randomly selected in the market, it was determined that a 317-mL serving of an average factory-made SSB is close to Indonesians' per capita daily SSB consumption. The data suggest that it is likely that SSBs are consumed in their entirety in one sitting.[26]

Following the WHO recommendation to limit free sugar intake to 5% to 10% of daily total energy intake (TEI),[27] once-daily consumption of SSB may already put an individual at risk of exceeding that limit. Using the upper limit of 10% of TEI, the daily free sugar intake allowance for adults and children aged under five years would be 50 g and 27 g–40 g, respectively.[7] The Ministry of Health of the Republic of Indonesia noted that free sugar intake of more than 50 g per day is excessive and recommends that it not exceed 25 g.[28] From the same 22 samples of SSBs, a 317 mL serving portion of an SSB contains 23 g of sugar or approximately 7.26 g per 100 mL. The fact that unhealthy choices in SSBs continue to dominate the local market, considering that the National Agency of Drug and Food Control/*Badan Pengawas Obat dan Makanan* (BPOM) classifies "healthy choices" in SSBs as containing no more than 6 g of sugar per 100 mL.[29] Consumption of SSB by itself, even once a day, can mean ingesting amounts of free sugar approaching the daily intake limits set by the WHO and the Ministry of Health.

Indonesians are introduced to SSBs at an early age. The Total Diet Study in 2014 indicated that 42.6% of children aged under five years consume SSBs, with the highest consumption (59.8%) among those aged 36–59 months.[30] High SSB consumption can also be reflected in the substantial proportion (67.19%) of household spending devoted to SSBs, as reported in the 2017 National Socioeconomic Survey/*Survei Sosial Ekonomi Nasional* conducted by Daeli and Nurwahyuni.[31] In line with these estimates, the 2018 of Basic Health Research survey,[32] indicated that 61.3% of Indonesians aged ≥3 years consumed at least one SSB per day (Figure 2), with

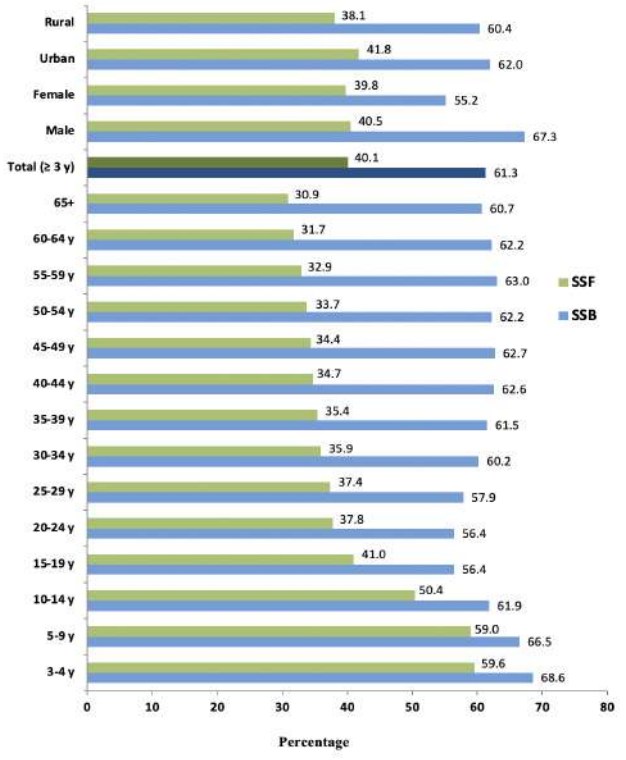


Figure 2. Individual Daily Consumption of Sugar-Sweetened Beverages and Sugar-Sweetened Foods by Age, Sex, and Location,[32]

consumption exceeding that of sugar-sweetened food (40.1%). Sugar-sweetened food consumption was higher in male than female Indonesians (67.3% vs. 55.2%), but no notable age- or location-based (rural vs. urban) differences in consumption patterns were observed.

These findings explain why the consumption of SSBs, regardless of origin, can be regarded as the most considerable source of per capita sugar intake in Indonesia and constitutes a potent risk factor of various relevant health conditions. Studies have consistently reported that SSBs account for almost 20% of the TEI of teenagers in East Jakarta,[33] and Bandung.[34] In addition, a systematic review on snack food or SSB consumption in young children in low- and middle-income countries (including Indonesia) reported a TEI of 13%–38% (median 19.3%), exceeding the maximum allowance of 10%.[35]

According to data from the 2017 National Socioeconomic Survey,[36] among all variants of SSBs (alcoholic or otherwise), soft drinks were the least popular. In contrast, ready-to-drink beverages such as coffee, milk coffee, tea, and chocolate milk were the most highly purchased and consumed. Using the same data set, Daeli and Nurwahyuni,[31] analyzed the determinants of SSB consumption in Indonesia. The consumption of fast food and processed snacks, the price of SSBs, and per capita income were found to be positively associated with SSB intake. This study revealed that SSB intake was reduced by 19.86% with every 10% price increase. Being aged 65 years or over was negatively associated with SSB consumption.

Health Outcomes Related to High Sugar-Sweetened Beverages Consumption

Thousands of published studies have addressed the negative health effects of SSB consumption, with evidence of the link between the two ranging from low, moderate, and strong (Figure 3).[1] Experimental tests indicated that SSB consumption may not necessarily induce satiety or self-regulation in the next food or drink consumed. A person's sensitivity to proper compensation for excessive caloric intake, especially following the consumption of liquids,[37] that are not solid sources of carbohydrates, appears to diminish by age or body adiposity.[38-40] These could lend a plausible explanation to why SSB consumption has been associated with conditions such as for overweight,[39,40] obesity,[41,42] fatty liver,[43] CMS,[44-47] and type 2 diabetes.[48,49]

Other studies have associated SSB consumption with risks of tooth decay,[50] kidney disease,[51-53] micronutrient deficiencies,[54-57] cancer,[58] strokes,[59] psychological dis-

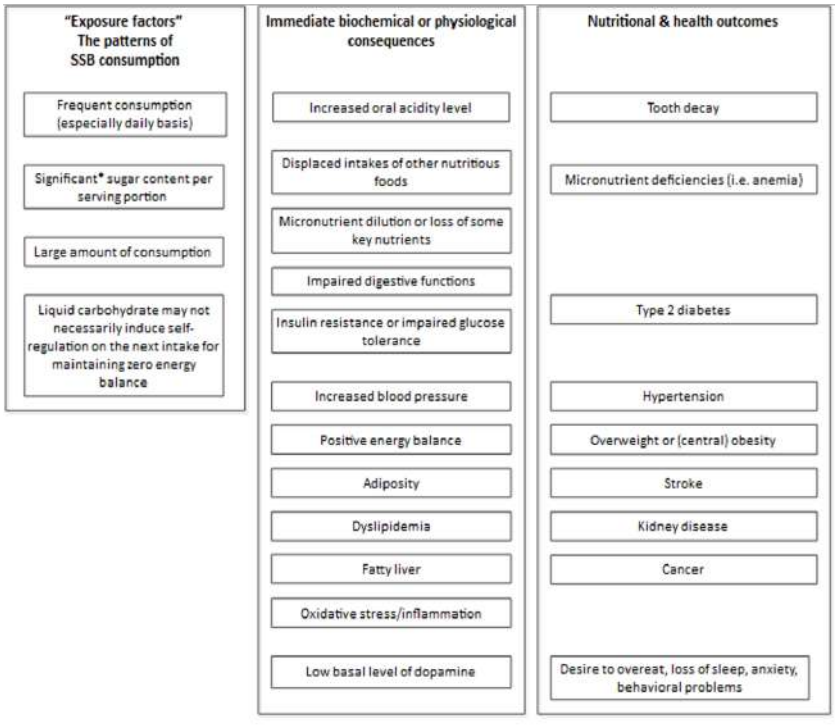


Figure 3. Immediate Biophysiological Consequences and Nutritional Health Outcomes Related to Sugar-Sweetened Beverages Consumption

orders such as anxiety, sleep loss,[60] and behavioral problems among preschoolers,[61] among others.[62] Such disturbances have been linked to the high sugar content and other substances (e.g., carbon dioxide, caffeine, and artificial sweeteners) in SSBs. Their consumption initially leads to some intermediate conditions such as positive energy balance, increased oral acidity level, impaired digestive function, and the insufficient intake or loss of certain key nutrients.

Health Outcomes that are Potentially Linked to High Sugar-Sweetened Beverages Consumption in Indonesia

Growing concerns about SSB-related health risks must be sufficiently addressed concerning the efforts to reduce SSB consumption in Indonesia, especially in consideration of trends in national health statistics within the past two decades, which have highlighted the emergence and population risk of NCDs as the persistent problem of undernutrition. The Global Health Estimates of the WHO,[63] NCDs attributed to 61.3% of deaths in 2000, 68.9% in 2010, 72.5% in 2015, and 73.3% in 2016—a clear upward progression. The National Basic Health Research survey in 2018,[32] reported that the onset of overweight in early infancy was 13.6%, declined approximately 5% to 6% between the ages of 6 and 59 months, and rose again after 5 years. As shown in Figure 4, the proportional distribution of individuals with obesity shifted from being lower to being consistently higher than that of individuals with overweight, with considerably significant proportional differences of more than 6% between the ages of 25 and 64 years. The percentage of girls and women with overweight aged ≤18 years was higher than boys and men with the same condition. In contrast, the percentage of boys and men with obesity was higher than that of girls and women with the same condition. Beyond that age, however, the proportion of women with obesity spiked almost sevenfold, far exceeding that of men with obesity.

Across all age groups, the prevalence of overweight and obesity was consistently higher in urban than rural areas (Figure 4). The proportional distribution patterns of overweight and obesity by age group were similar by location (e.g., urban or rural), with a higher prevalence of overweight than obesity in individuals aged less than 18 years. At and over the age of 18 years, obesity was more prevalent than overweight. Across years, the prevalence of overweight and obesity rose steadily across all age groups, with the most striking increase in the preva-

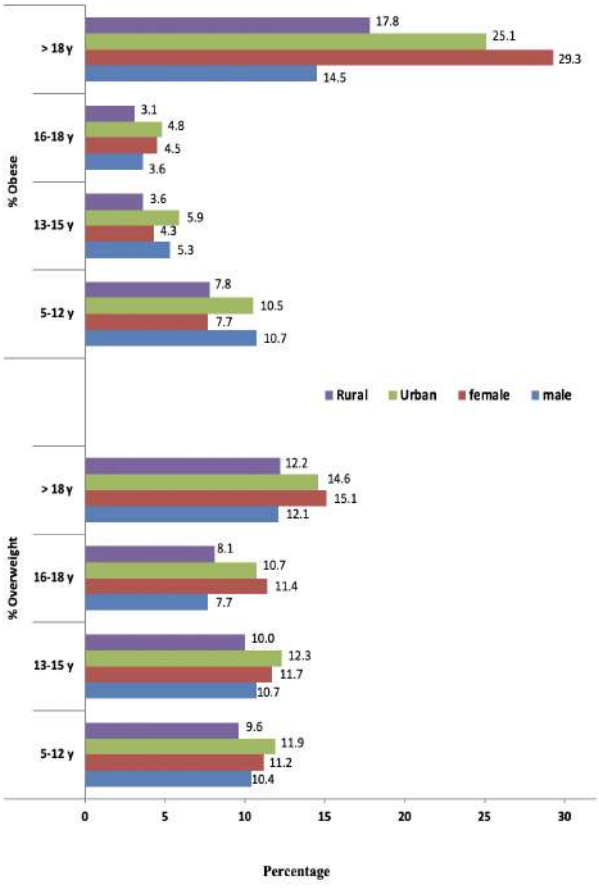


Figure 4. Prevalence of Overweight and Obesity by Age Group,[32]

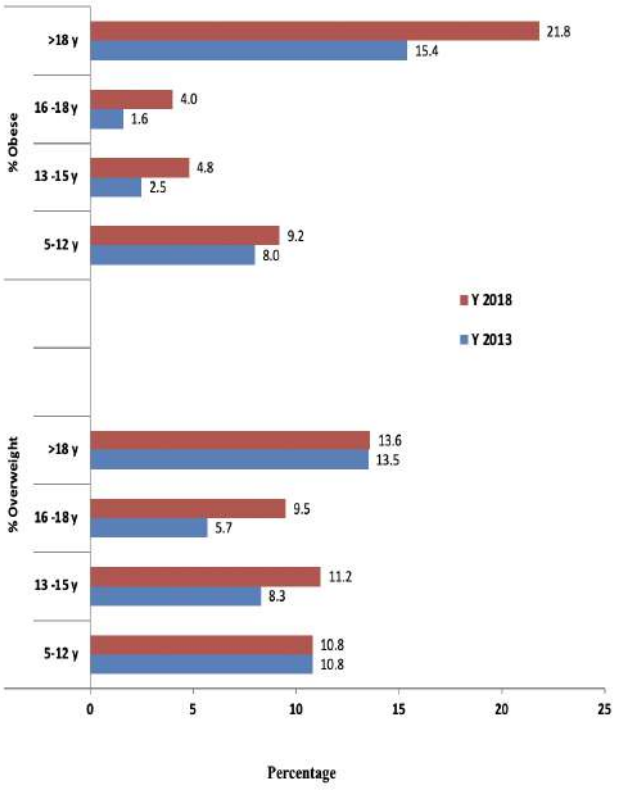
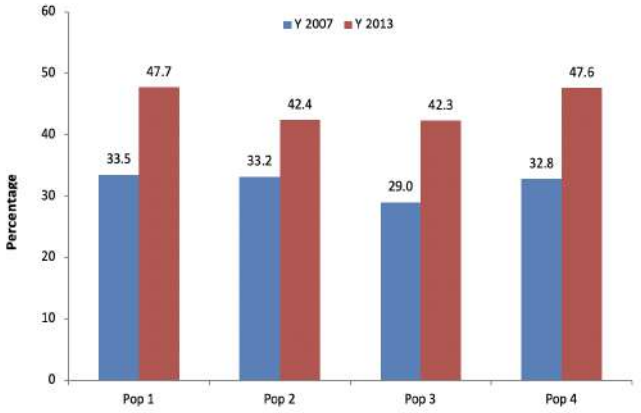


Figure 5. Prevalence of Overweight and Obesity by Age Group Across Years,[32,64]

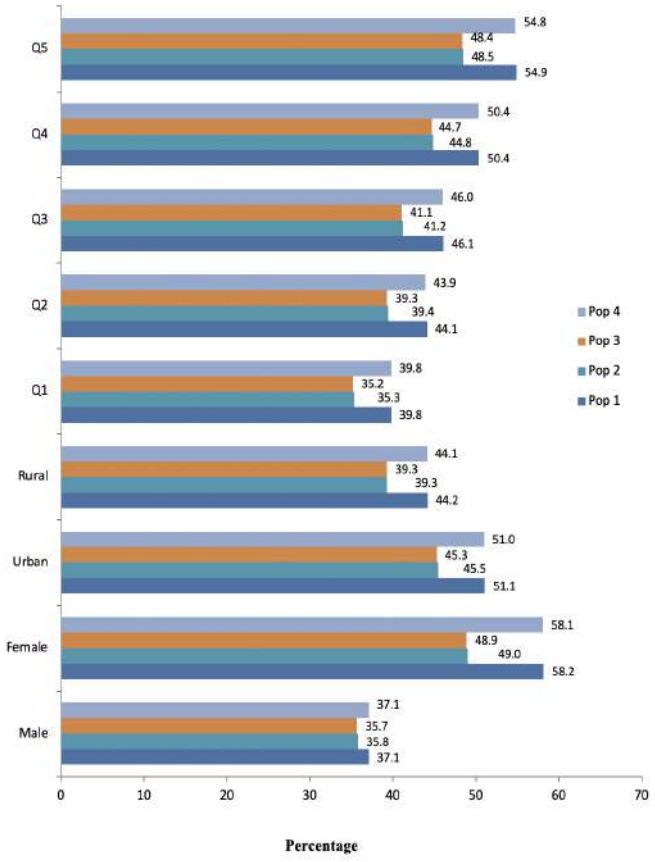


Notes: Population 1: Hypertension, diabetes, cancer, obesity, central obesity; Population 2: Hypertension, diabetes, cancer, obesity; Population 3: Hypertension, diabetes, obesity; Population 4: Hypertension, diabetes, obesity, central obesity.

Figure 6. Prevalence of NCDs Across Years,[64,65]

lence of obesity in those aged 18 years or over from 15.4% to 21.8% between 2013 and 2018 (Figure 5).

Between 2007 and 2013, the prevalence and risk of NCDs among individuals aged 18 years or over increased by approximately more than 1% (Figure 6). Statistics from the National Basic Health Research survey in 2013,[64] indicated that NCD prevalence and risk were higher among women living in urban areas and those of a higher socioeconomic class (including women with both of these attributes; Figure 7). More detailed analysis is warranted for interpreting whether this higher prevalence means a higher risk of developing NCDs and/or is ascribable to higher compliance to medical care. Aside from the prevalence differences, statistics from the 2007,[65] and 2013,[64] National Basic Health Research survey indicate that NCDs constitute a serious public health concern (Figure 6 and 7).



Notes: Population 1: Hypertension, diabetes, cancer, obesity, central obesity; Population 2: Hypertension, diabetes, cancer, obesity; Population 3: Hypertension, diabetes, obesity; Population 4: Hypertension, diabetes, obesity, central obesity.

Figure 7. Prevalence of NCDs by Sex, Location, and Socioeconomic Class,[64]

Conclusion and Recommendation

Understanding the potential contributions of Indonesia's high SSB consumption is exigent as CMS, and any other health conditions show increasing trends over time. Some relevant indicators from the National Basic Health Research survey in 2018 can be a preliminarily study to examine any correlations in SSB consumption with the population's dietary quality and nutritional outcomes by age group, sex, socioeconomic class, and location (urban/rural and geographical). Future studies are required to estimate better Indonesia's annual financial and non-financial losses (e.g., in terms of government health spending and disability-adjusted life years, respectively) attributable to NCDs. These estimates can form a strong foundation for developing policies on limiting the population's sugar intake, including SSBs.

On the supply side, four approaches to lower SSB consumption are proposed as follows: (1) enforcing regulations to limit the sugar content of any form of SSB and provide complete nutritional information, particularly total sugar content; (2) promoting both the production and consumption of products containing less sugar; and (3) reinforcing interventions on retail and food services to set beverages with less sugar as default options, offer more of such products on counters, or even apply strict conditions on selling products with substantially high sugar content; (4) and pursuing further study, academic reviews, and debates on empiric policies to control sugar consumptions at the population level.

Equally importantly, on the demand side, practical educational approaches must be explored and implemented to modify Indonesians' sweetness preferences, with adjustments made for age groups and sociocultural contexts. Such education must strongly emphasize the following: (1) the health benefits of reducing free sugar intake (including that from SSBs) and (2) promoting

healthier eating habits among the population, including the limitation of sugary food and drink, starting from an early age.

Abbreviations

SSB: Sugar-Sweetened Beverages; NCDs: Noncommunicable Disease; WHO: World Health Organization; CMS: Cardiometabolic Syndrome; PG: *Pabrik Gula* (Sugar Factory); TEI: Total Energy Intake; BPOM: *Badan Pengawas Obat dan Makanan*; g: gram; mL: milliliter; Riskesdas: *Riset Kesehatan Dasar*.

Ethics Approval and Consent to Participate

Not Applicable

Competing Interest

The author declares 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 dataset used and analyzed are available in published documents and the internet.

Authors' Contribution

All authors contribute to the conception and construction of the review outline and the compilation of references. Furthermore, RADS, A, MIZB, SB, and WL provide input on substantial elements of the review, research implications and near future policy development, considerations on the political implication of the review. LW coordinated communication between experts, synthesis the review, aligned the progress of the draft review with recommended time frame provided by the donor. WL also coordinated funding support from the donor and the final editing of the draft manuscript.

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Increased Thyroid Hormone Levels in Pesticide Sprayer at Agricultural Area

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Abstract

Pesticides used massively in the agricultural sector would cause many poisoning and serious health problems. Organophosphate pesticides have been identified as endocrine-disrupting chemicals. This study aimed to compare thyroid hormone levels between the sprayers chronically exposed to pesticides and the control respondents who had never been exposed to pesticides. This study was an analytical observational with a cross-sectional design. The total number of respondents was 150, 50 as sprayers and 100 as control respondents. The venous blood samples were examined using the Enzyme-Linked Immunosorbent Assay (ELISA). The findings significantly showed that the sprayer had a higher level of thyroid-stimulating hormone (TSH) (4.776 ± 1.1166), lower triiodothyronine (T_3) (108.822 ± 18.810), and lower thyroxine (T_4) (7.808 ± 1.067). Determinant factors among sprayers that significantly correlated to TSH levels was age (p-value = 0.006); work duration (p-value = 0.000); personal protection equipment (PPE) (p-value = 0.045); body position (p-value = 0.014); type of pesticides (p-value = 0.004), correlated with T_3 levels was age (p-value = 0.037); body position (p-value = 0.045), correlated with T_4 levels was age (p-value = 0.000); PPE (p-value = 0.045). It could be concluded that chronic organophosphate exposure would increase TSH and decrease T_3 and T_4.

Keywords: endocrine-disrupting chemicals, health risks, thyroid-stimulating hormone, T_3, T_4

Introduction

Chemical pesticides used massively in the agricultural sector are increasingly undeniable and unstoppable, especially in developing countries. The Food and Agriculture Organization (FAO) of the United Nations showed data from 1990 until 2017, the worldwide use of pesticides was increased by 2.01 million tons.[1] Pesticide kill pests and unwanted plants that potentially damage the agricultural product applied throughout the planting season.[2] The high demand for fruits and vegetables with perfect physical condition causes farmers to have no choice other than to use pesticides all over time. Furthermore, worldwide chemical pesticides usage in large quantities for lasting decades impacted human health and the environment.[3-6]

Organophosphate pesticides have been reported as endocrine disruptors chemicals affecting many organ systems.[7,8] A comparison study in conventional and organic farmers in Thailand showed that conventional farmers have thyroid-stimulating hormone (TSH) levels of 1.6 times higher than organic farmers. Some herbicides have a significant relationship between the doses and increased thyroid hormone.[9] Another study in pregnant women who lived in a floricultural area of Mexico showed their TSH was affected when those husbands had an occupation involving contact with pesticides.[10] In a cross-sectional study in Brazil, cumulative exposure to pesticides can affect thyroid function and cause hypothyroidism, especially in men.[11]

Batu City is in a mountainous area with fertile land, good quality water, fresh air, and the right temperature made it suitable for agriculture activities and has long been known as one of the best fruits and vegetable producing regions in Indonesia. The planting period from June to September causes the use of increasing pesticides. Indonesia's fruit and vegetable plant area is 11,697,807 Ha, East Java 1,121,448 Ha, and Batu City is 15,258.09 Ha.[12,13] The physical characteristics of horticultural products, primarily fruits and vegetables that are easily damaged and take place, require visual quality-based requirements such as size, color, smell, and freshness. They tend to overuse pesticides to secure their products.

Factually, most farm sprayers do not use adequate personal protective equipment (PPE) to protect their

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bodies from chemical pesticides exposure. Sometimes they also use pesticide doses that are not according to the rules and do not use the correct spraying method to kill pests fastly. This condition is hazardous to cause acute and chronic poisoning among sprayers. Moreover, some of the pesticides used are identified as systemic poisons that can interfere with hormone production in the body, and they do not realize there are side effects from it. This study aimed to analyze a comparison in thyroid hormone levels, including TSH, T_3, and T_4, between the sprayer pesticides that were chronically exposed to pesticides and the respondents that had never been exposed to pesticides. Thus the local government can take preventive action so that the level of pesticide poisoning can be minimized.

Method

This study was an observational analytic with a cross-sectional design. Data were collected simultaneously and conducted on agricultural areas during planting season from September 2018 to February 2019. Male respondents were chosen using simple random sampling with a proportion of 1:2 between two groups of respondents. The total number of respondents was 150 and originated from two different populations. Fifty male active pesticides sprayers participated as exposed respondents from fruit plantations. Simultaneously, 100 male workers were nonexposed respondents from the same area with similar sociodemographic status. It was ensured that nonexposed respondents never contacted pesticides in agriculture. Respondents who had never received high doses of iodine capsules in the last five years were particular inclusion criteria.[14] While the exclusion criteria for respondents who suffered from chronic diseases and complications.[15]

Data collection was done through interviews, observations, and laboratory examinations. Serum of TSH, T_3, T_4, and age variables were taken from both types of respondents. Simultaneously, the additional data taken from exposed respondents were work duration, the use of PPE, body position when spraying, and the type of pesticides used in the last three months. The laboratory would test serum of TSH, T_3, and T_4. Data of age, work period, and length of work were taken using a questionnaire. While PPE, body position, and type of pesticides have been taken using the observational form. Variable of body mass index (BMI), alcohol intake, smoking, stress level were excluded from this study because from preliminary study showed no variants between respondents.

Venous blood samples were taken as much as 5 mL by laboratory medical analyst staff, both exposed and nonexposed respondents. Blood samples that have been taken immediately poured into a vacutainer tube for prevented blood clotting before centrifugation. Each tube would be labeled with specific information from the respondent and transferred into the laboratory. Blood samples were centrifuged at the temperature room at 4,000 rpm/10 minutes to take the serum. Before proceeding with the assay, all reagents, serum reference calibrators, and controls were let at room temperature (20-27°C). The microplate wells for each serum calibrator, control, and patient specimen were assayed in duplo. Any unused microwell strips were replaced back into the aluminum bag, sealed, and stored at 2-8°C. Then, pipette 0.025 mL (25 µL) of the appropriate serum specimen into the assigned well for fT_4 (pipette 0.050 mL (50 µL) for fT_3, and pipette 0.025 mL (25 µL) for TSH). Next, 0.050 mL (50 µL of Enzyme Reagent fT_4 or fT_3 was added to the appropriate wells (for TSH, add 0.100 mL (100 µL) of TSH Enzyme Reagent). The microplate was swirled gently for 20-30 seconds to mix and cover and added 0.050 mL (50 µL) of biotinylated x-fT_4 or (x-fT_3) reagent to the appropriate wells (for TSH, this step could be skipped). The microplate was swirled gently for 20-30 seconds to mix and cover, then incubated for 60 minutes at room temperature. The contents of the microplate were discarded by decantation or aspiration. If decanting, blot the plate dry with absorbent paper, and add 0.350 mL (350 µL) of wash buffer. Repeat two (2) additional times for a total of three (3) washes using an automatic or manual plate washer, and follow the manufacturer's instruction for proper usage. If a squeeze bottle is occupied, fill each well by pressing the container (avoiding air bubbles) to dispose of the wash. Decant the wash and repeat two (2) additional times. Lastly, 0.100 mL (100 µL) of substrate solution was added to all wells. It is important to always add reagents in the same order to minimize reaction time differences between wells. The examination of serum concentration levels from TSH, T_3, and T_4 used the ELISA technique.[16]

Data were analyzed using the IBM SPSS Statistics 23. Respondent data with a ratio scale were first be tested for normality using Kolmogorov-Smirnov, such as TSH, T_3, and T_4. The data showed was not normally distributed, then it would be followed by Mann-Whitney analysis to find out the differences between two groups of respondents. A linear regression analysis test with dummy variables were performed to determine the factors influencing the variation of hormones in exposed respondents.

Results

The serum TSH levels, T_3, and T_4, in the two groups of respondents were statistically tested whether it could be seen that there were significant differences, as shown in Table 1. Differences in serum levels between exposed and nonexposed respondents showed significant statistical test results with p-values (0.000) < 0.05. The serum TSH levels of the exposed respondent had significantly higher means, whereas serum T_3 and T_4 had lower means

levels.

The Table 2 of risk factors in the exposed respondents: 24 respondents age was more than 50 years old, 24 respondents had worked for 5-10 years, 25 respondents used simple PPE that did not meet the requirements, 32 respondents did not adjust the positioning body with the wind direction when spraying pesticides, and 25 respondents use organophosphate pesticides. The statistically tested factors significantly influenced increasing TSH levels and decreasing T_3 and T_4 in respondents exposed to pesticides shown in Table 3.

Analytic statistical test of risk factors for serum TSH, T_3, and T_4 levels in the exposed group showed in Tables 3, age had a significant effect on all serum levels, work duration had a significant impact on serum TSH levels, the use of inappropriate PPE affected the serum TSH levels, and T_4 the body's adjustment to the wind direction affects the levels of TSH and T_3, and the type of pesticide used affects the serum TSH level.

Discussion

Pesticides play an essential role and are extensively used in modern agricultural systems worldwide. By 2020, global pesticide usage is estimated at approximately 3.5

Table 1. Descriptive and Analytical Statistics of Thyroid-Stimulating Hormone, T_3, and T_4 Levels from Exposed and Nonexposed Respondent

Group	Category	TSH (µIU/mL)	T_3 (ng/dL)	T_4 (µg/dL)
Exposed respondent (n = 50)	Mean	4.776±1.1166	108.822±18.810	7.808±1.067
	Maximum	6.8	146.2	9.6
	Minimum	2.3	82.5	5.5
Nonexposed respondent (n = 100)	Mean	3.504±0.971	146.302±18.635	9.955±1.136
	Maximum	5.2	182.5	11.9
	Minimum	1.5	109.4	8.2
p-value		0.000*	0.000*	0.000*

Notes: *) Significant level (p-value<0.05), TSH = Thyroid-Stimulating Hormone, T_3 = Triiodothyronine, T_4 = Thyroxine

Table 2. Distribution Frequency of Risk Factor on Active Pesticide Sprayers

Risk Factor	Category	n	%
Age (years old)	<30	8	16
	31-50	18	36
	>50	24	48
Work duration (years)	<5	5	10
	5–10	24	48
	>10	21	42
Personal protective equipment (PPE)	Full coverage body	6	12
	Simple and meet the requirement	19	38
	Simple and did not meet the requirement	25	50
Body position	Adjusted with wind direction	18	36
	Not adjusted with wind direction	32	64
Type of pesticides	Non-Organophosphate	25	50
	Organophosphate	25	50

Table 3. A Linier Regression Test for Determinant Factor with Level Thyroid-Stimulating Hormone, T_3, and T_4 on Active Pesticide Sprayers

Determinant Factor	Category	TSH (µIU/mL)	T_3 (ng/dL)	T_4 (µg/dL)
Age	p-value	0.006*	0.037*	0.000*
	Standardized coefficient	0.216	-0.289	-0.526
Work duration	p-value	0.000*	0.692	0.399
	Standardized coefficient	0.429	-0.066	-0.130
Personal protective equipment (PPE)	p-value	0.045*	0.990	0.045*
	Standardized coefficient	0.127	-0.002	-0.277
Body position	p-value	0.014*	0.045*	0.646
	Standardized coefficient	0.211	-0.307	-0.462
Type of pesticides	p-value	0.004*	0.206	0.386
	Standardized coefficient	0.224	-0.169	-0.107

Notes: *) Significant level (p-value<0.005), TSH = Thyroid-Stimulating Hormone, T_3 = Triiodothyronine, T_4 = Thyroxine

million tons, where China is the top, followed by the USA and Argentina. Farmers use pesticides to prevent planthopper pests and improve the quality of agricultural products. Many pesticides cause acute, chronic poisoning, and death in developing countries as toxic chemicals.[17-19] Poisoning of pesticides mainly occurs during preparation and application, such as mixing, loading, spraying, and cleaning the equipment. Hence, the agricultural workers mostly got chronic poisoning because they were repeatedly exposed to adverse health effects and death.[20,21] The study in Batu City in 2019 showed that some sprayers had decreased their hemoglobin levels.[22] Also, some pesticides are classified as Endocrine Disruptor Pesticides, which would disrupt all the human body's hormonal system and genome activity; in specific periods, it damages organs and tissues that play major carcinogenesis for an extended period.[23-25]

Globally, an estimated 1.8–2.2 billion people are at risk of exposure to pesticides from the agricultural sector. The highest potential for pesticide poisoning is formulators and sprayers because they are at increased risk since they handle pesticides, toxic chemicals, toxic solvents, and inert carriers.[21,26] Some studies to predict pesticide exposure using the Agricultural Operator Exposure Model (AOEM) on formulators and sprayers has been shown that more than 50% of respondents have exceeded the Acceptable Operator Exposure Level (AOEL) for daily exposure, this caused increased health risks due to accumulation of active ingredients of pesticides, especially organophosphate pesticides.[27,28]

This study found that the exposed pesticides respondent had a mean level of serum TSH significantly higher than the nonexposed respondent. In contrast, the mean level of serum T_3 and T_4 was significantly lower in exposed respondents, as shown in Table 1. Some studies previously documented in pesticides sprayer and farmers that certain herbicides, fungicides, and insecticides are thyroid disruptors, which had different impacts on the rest of the population.[28-30] This study controlled several variables that could affect serum thyroid hormone levels, such as iodine tablet consumption and a history of chronic disease. It could be ascertained that differences in serum levels of thyroid hormone between the two groups are indeed caused by exposure to pesticides. The same results were shown in a study in Iran conducted on 40 sprayers and 20 controls by controlling variable chronic disease, alcohol consumption, and diabetes status.[31] The thyroid hormone production is through a series of peroxidation reactions that require iodide, hydrogen peroxide, thyroid peroxidase enzymes, and iodine acceptor proteins.[32] Thyroid peroxidase enzyme (TPO) was essential key to producing or synthesizing TSH, T_3, and T_4 and major autoantigen in autoimmune thyroid diseases.[33] The TSH measurement was very useful for evaluating thyroid function. Next, measurements such as T_3 and T_4 will complete the diagnosis of thyroid disorders. This study could be classified as the exposed respondent to be hypothyroidism or hyperthyroidism.

The field observations showed that respondents used organophosphate, carbamate, and pyrethroid pesticides. They used pesticides in various active ingredients: mancozeb, heptachlor, aldicarb, chlorpyrifos, cypermethrin, and dichlorvos. Some results of the biomarker study showed that mancozeb is classified as an anti-TPO chemical; thereby, they would consider the changeability of follicular cells that reduce T_3 and T_4 production in humans even at sufficient iodine concentration.[34] The study review results also showed that heptachlor, aldicarb, chlorpyrifos, cypermethrin, and dichlorvos were included in the list of endocrine disruptor pesticides, which might disrupt progesterone, estrogen, and androgen activity.[35] Most sprayers and formulators in this study were not aware of the health hazards of the toxicity of pesticide poisoning. They stated that the pesticide used was the most widely used hereditary and proven effective in driving out planthopper pests and would continue it for the next planting period.

This study also calculated the potential risk of several factors expected to influence thyroid hormone synthesis in the sprayer and formulator body. As shown in Table 3, all the risk factors analyzed with statistical tests correlate significantly with the synthesis of thyroid hormones such as TSH, T_3, and T_4. Positive correlations occurred at serum TSH levels, whereas negative correlations at T_3 and T_4 levels showed in the linear regression test. Increased respondents' age, longer duration of work, use of PPE that did not meet requirements, body positions that did not adjust to wind direction, and organophosphate pesticides would increase TSH levels in the body and cause T_3 and T_4 levels to decrease. This result was in line with research conducted on 122 greenhouse workers in Danish that in the spring or planting season, the mean of TSH levels increased while T_3 and T_4 levels decreased; it was caused plants need more pesticide intake.[36] This case was also shown in Brazil's agricultural population that their thyroid hormone increased in the peak of planting season.[11] This study's sprayers and formulators said they worked almost every day because they had to spray pesticides on several plantations. When it is close to the harvest period, it should be sprayed more frequently to maintain the fruits and vegetable quality. It could be ensured that pesticides are highly exposed to their body almost every day.

Statistical analysis in this study showed that the increase of the exposed respondent's age was significantly correlated and impacted increasing TSH levels by 0.216, decreasing T_3 by 0.289, and T_4 by 0.526. This result was supported with analysis using Agricultural Health Study

data at 22,246 male sprayers showed that participants without thyroid disease, those in each thyroid disease category, were more likely to be older with an average age of 45.6±12 years.[37] A similar study also showed that age molecular disease (AMD) was positively associated with thyroid function (OR = 7.9) in sprayer pesticide cases.[38] The respondents in this study said they had consistently worked as a pesticide sprayer since they were young; therefore, it would simultaneously extend their working duration. Statistical analysis showed that the work duration would significantly be increasing TSH levels by 0.429. This work duration indicates that the respondent has been chronically exposed to pesticides.

Experience and knowledge are needed to protect the body from these chemicals in applying pesticides. Body adjustment to the wind direction does require experience and awareness of each sprayer. Investigation of the respondents showed that they do not consider wind direction. This study found that it was statistically proven that the proper adjustment of the sprayer's body position while avoiding the drift of pesticides was a protective factor in reducing the dose of pesticides absorbed in the body. This result was in line with the study in Ghana that the majority of sprayer disregards drifts of pesticides towards the body, including their face when wind blowing.[4] The pesticide spraying protocol states that it must avoid sensitive areas of the body from pesticide drifts and stop immediately when the wind is not constant and not assured.[39]

Some respondents said that using complete PPE when spraying would put excessive strain and reduce the movement's effectiveness. They tend to use improvised personal protective equipment. Further investigation showed that in the middle of the spraying process, respondents removed the PPE portion because they felt it was too hot. As is known, there are three main pathways for the entry of pesticides into the human body, including skin contact, ingestion, and inhalation.[20] Previous studies showed a significant correlation between using the appropriate PPE and acute poisoning.[40] Furthermore, wearing four or more PPE had a lower prevalence of acute poisoning.[4,41] One of the last defenses in preventing the entry of toxic chemicals into the body was to use an appropriate PPE that covers the entire toxicant pathway.

Conclusion

The conclusion from this study that the significant difference in the sprayer has a higher level of thyroid-stimulating hormone (TSH) (4.776±1.1166), lower triiodothyronine (T_3) (108.822±18.810), and lower thyroxine (T_4) (7,808±1.067) compare to the respondents that had never been exposed to pesticides. This health risk is faced by pesticide sprayers who work daily in the agricultural area, mainly fruit plantations. The linear regression result test shows that the determinant factors that strongly influence TSH, T_3, and T_4 in pesticides sprayer include age, work duration, personal protective equipment, sprayer body position, and type of pesticide. Based on this study's results, the authors recommend that groups constantly exposed to pesticides use personal protective equipment that meets the requirements and pay attention to all good practices in pesticide application. The authors also suggest farmer groups as community organizations that oversee farmers and sprayers to conduct coaching and share experiences among members routinely.

Abbreviations

FAO: Food and Agriculture Organization; TSH: Thyroid-Stimulating Hormone; T_3: Triiodothyronine; T_4: Thyroxine; Ha: Hectare; mL: milliliter; PPE: Personal Protective Equipment; BMI: Boddy Mass Index; ELISA: Enzyme-linked immunosorbent assay; rpm: Revolutions per Minute; ng/dl: nanograms per deciliter; µIU/mL: micro-international units per milliliter; µg/dL: micrograms per deciliter; USA: The United States of America; AOEM: Agricultural Operator Exposure Model; AOEL: Acceptable Operator Exposure Level; TPO: Thyroid Peroxidase; AMD: Age Molecular Disease; OR: Odds Ratio.

Ethics Approval and Consent to Participate

Respondents received detailed explanations for rights and obligations when participating in this study. Without pressure from the research team, respondents who agreed participated in giving their informed consent before blood specimen collection and interviews. The Ethics Committee granted ethical approval from the Faculty of Public Health, Universitas Airlangga, with number 227/HRECC.FODM/V/2019.

Competing Interest

The author declares 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 used and analyzed during the current study are available in the authors' internal database. Please contact the corresponding author to get the data.

Authors' Contribution

ASP contributed to analyzing and writing subchapter abstracts and discussion, KCD contributed to data collection, plotting data, and writing subchapter introduction and methods, while MTL contributed to all reviews of this manuscript. BHS and MFDL contributed to preparing instruments collecting data, and writing subchapter results and conclusions.

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Body Image, Quality of Life, and Their Predicting Factors in Pregnant Women: A Cross-Sectional Study

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Abstract

Pregnancy can influence women's psychological health, including body image and quality of life. This study aimed to examine the relationship between body image and quality of life and their predicting factors in pregnant women. This cross-sectional study was conducted on 250 pregnant women referred to health centers in Ilam City, Iran. Participants were selected using a random sampling method. Data collection tools comprised a sociodemographic questionnaire, Body Image Concern Inventory (BICI), and quality of life questionnaire (Short Form-12). Data were analyzed using statistical software. The mean ± SD of body image concern and quality of life was estimated at 31.77 ± 9.86 and 54.62 ± 15.71, respectively. There was a significant and negative correlation between body image and quality of life (p-value = 0.001, r = -0.313). Also, the most important predictors of body image were vitality, body mass index (BMI), general health, and unintended pregnancy, respectively, and body dissatisfaction was the most significant predictor of quality of life. This study revealed some variables affecting pregnant women's body image and quality of life. Further studies are required to consider other factors influencing body image and quality of life among pregnant women.

Keywords: body image, pregnant women, quality of life

Introduction

Pregnancy is a unique experience that can be accompanied by important physical, mental, and social changes.[1,2] During pregnancy, underlying alterations occur in women's appearance, body mass index (BMI), and body image, affecting their quality of life.[3,4] Body image is a multidimensional construct encompassing perceptions, attitudes, beliefs, feelings, and behaviors regarding one's appearance and also is an essential aspect of mental health that a mistake perception from body image can lead to psychological and physical problems.[5,6] Body image also refers to the person's view, negative and positive thoughts, mental picture and the perception of own physical body, and the attitude towards own physical body formed since birth and is complete by the development of an individual and change over the life stages.[7]

Body image may undergo disruption in response to changes and factors such as puberty, aging, pregnancy, and increased BMI, type of social behavior, and social factors like visual media, normative pressure on family and society, and standards and aesthetic definition in society.[8-11] Overweight and obesity in women of reproductive age are increasing and considered a critical challenge.[12] These changes in pregnancy are accompanied by dissatisfaction that leads to women's body image disturbance.[13] This dissatisfaction means a negative investigation from the body that its prevalence is growing. Continuity of this dissatisfaction during pregnancy leads to problems such as depression, social distress, decreased social participation, decreased self-esteem, the feeling of being unattractive, and intellectual conflict relative to appearance, which can, in turn, result in one's daily dysfunction.[10,14,15]

Hence, pregnant women turn to different ways, such as using a restrictive and unscientific diet and doing tough and intolerable sports to achieve the ideal body image, affecting maternal and infant health.[16,17] These can lead to inadequate weight gain, anemia, premature rupture of the amniotic sac, newborn with low Apgar scores, premature delivery, preterm delivery, low-birth-weight infant, and even infant and maternal mortality.[18,19] Organic, hormonal and psychological changes along with factors such as economic status, stressful events, and body image disturbance can change one's ability for doing the usual roles of life during pregnancy, affecting both maternal and infant health.[20]

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Quality of life (QOL) is an important concept that has been considered in many studies, especially in medical and health sciences. The QOL is a multidimensional dynamic concept that affects the performance of individuals in physical, psychological, social, and spiritual aspects of life.[21] The World Health Organization (WHO) defines QOL as individuals' perception of their position in life in the context of the culture and value systems in which they live and concerning their goals, expectations, standards, and concerns. So, QOL is a subjective issue, which is not observable by others and is based on individuals' perceptions of different aspects of life.[22,23] Besides, QOL has become an area of increasing importance to maternal and child health. Pregnant women's perception of their quality of life is an essential measure of the quality and effectiveness of maternal and child health interventions.[24]

Few studies have investigated the relationship between body image concern and quality of life to the best of the authors' knowledge. There were few studies published to date which have examined the relationship between these concepts in pregnant women. Furthermore, QOL and body image are concepts affected by communities' cultural and social systems. The results of studies performed in western countries were not applicable in other countries, especially in Iran. Therefore, this study aimed to examine the relation between body image concern and quality of life and their predicting factors in pregnant women referring to health centers in one western city in Iran.

Method

This study used a descriptive-analytic method. The study population included all eligible pregnant women. Inclusion criteria were: a) having consent to enter the study; b) completion of the questionnaire entirely; c) writing and reading ability; d) aged 18 years and over; e) singleton pregnancy; f) gestational age of six weeks and above, and residing in Ilam City. The exclusion criteria were: a) unwillingness to continue being involved in the study; b) the history of underlying diseases; c) eclampsia and preeclampsia; d) smoking or taking sedatives medications and having mental diseases.

Sampling was conducted using a cluster sampling method. The study setting was comprehensive health centers of Ilam City in the west of Iran. So, Ilam City was divided into five geographical areas (north, south, center, east, and west). Then, two comprehensive health centers were randomly selected from each zone. Each zone was considered to be a cluster. Since the number of individuals covered by each center was different, the required sample within each center was computed based on cluster sampling. After reviewing the health record of each household, those who were eligible were identified and invited randomly to participate in this study. The sample size was estimated at 240 subjects based on the Formula 1 with d = 0.05, z = 1.96, p-value = 0.2. From 270 pregnant women invited to participate, 250 agreed to participate in this study, considering a dropout rate of 10%.

$$\left[n = \frac{z_{1-\alpha/2}{}^2 p(1-p)}{d^2} = 240\right]$$

Formula 1. Sample Size Estimation

This study's data collection tools consisted of a study-made sociodemographic questionnaire, Body Image Concern Inventory (BICI), and quality of life questionnaire (Short Form-12). Participants' self-report completed the questionnaires. The first section was the sociodemographic questionnaire. This questionnaire included ten questions, including age, gestational age, weight during pregnancy, height, education status, habitation status, employment status, husband's support, economic status, the timing of pregnancy, pregnancy status, the month of pregnant, exercise during pregnancy, craving during pregnancy, use of medication, and abortion history.

The second section was Body Image Concern Inventory (BICI), designed by Littleton, *et al.*,[25] This questionnaire was a 19-item self-report measure designed to assess dysmorphic body image concerns. For each item, respondents were asked to rate how often they had the described feeling or performed the described behavior on a Likert scale anchored by 1 = never and 5 = always. The total score of this questionnaire ranges from 19 to 95, with a higher score indicating the amount of dissatisfaction with body image or one's appearance. Littleton, *et al.*,[25] have also examined the factor structure of the questionnaire. The results showed two crucial and significant factors. The first factor with eleven items (1-3-5-8-9-14-15-16-17-18-19) described dysmorphic appearance concern, checking, and disguising defects. The second factor with eight items (2-4-6-7-10-11-12-13) described interference in functioning due to appearance. The reliability of the questionnaire was measured by Littleton, *et al.*,[25] using the internal consistency method, with a Cronbach alpha coefficient of 93%. The correlation coefficient of each item with the total score of the questionnaire was between 32%-73% with a 62% mean. Also, the Cronbach alpha coefficient of the first and second factors were 92% and 76%, respectively, and the Correlation coefficient between the two factors was reported to be 69%. In Iran, the reliability of this questionnaire in the study of Elah MN, *et al.*, and Heidari M, *et al.*, were assessed, and using the Cronbach alpha coefficient was estimated at 78% and 84%, respectively.[26,27] In this study, the reliability of the questionnaire for the first and second factors were estimated at 76% and 81%,

respectively, using the Cronbach alpha coefficient of 87%.

The third section was the quality of life questionnaire (Short Form-12), a short form of SF-36. This questionnaire consisted of eight subscales, including individual perceptions of general health (1 item), bodily functioning (2 items), physical health (2 items), physical problems (2 items), bodily pain (1 item), social functioning (1 item), energy and vitality (1 item), and mental health (2 items). The first four subscales indicated physical of health-related quality of life (HRQOL) and the last four indicated mental HRQOL. The reliability and validity of the questionnaire had already been evaluated by Montazeri, *et al.*,[28] and the reliability of 12-items for the mental and physical domains was approximately 73% and 72%, respectively.

Data were analyzed using SPSS (version 22, SPSS Inc., Chicago, IL). Descriptive statistics such as percentage, mean, and standard deviation (SD) were used for assessing sociodemographic characteristics and associated with participants' pregnancy. Analysis of variance (ANOVA) and independent t-test was applied to compare the mean scores of participants' quality of life and body image concern based on the sociodemographic variables associated with pregnancy. Pearson correlation coefficient was used to test the correlation between dimensions of quality of life and body image concern. Moreover, multiple linear regression was applied to determine the predictors of body image concern and pregnant women's quality of life. Variables that were significant in bivariate analysis were entered to model using the stepwise method.

Result

The mean ± standard deviation (SD) of age, height, and BMI of participants were found as 28.8±5.08, 161.2±5.93, 28.07±3.63, respectively. The duration of marriage was less than five years in 54.6% of participants. The majority of participants (74.4%) lived in urban areas. For the education background, 56.4% had tertiary education. More than half of the participants had high economic status, 85.6% reported intended pregnancy, 52.7% performed exercise activities, 80% had no abortion history, and 78.8% had no history of taking medication during pregnancy. The BMI of 80.8% of participants was more than 25, and 76% had body image concerns (Table 1).

According to the results, the mean ± SD total score of pregnant women's quality of life was 54.62±15.71, and the lowest and highest score was related to the role limitation due to physical problems and fatigue dimension, respectively. The mean ± SD total score of body image concern was found at 31.77±9.86. The body dissatisfaction dimension had the highest score compared to other body image dimensions (Table 2).

As shown in Table 3, the mean body image was higher among those with better economic status (p-value = 0.001), those with unintended pregnancy (p-value =

Table 1. Frequency Distribution of Individual and Underlying Variables among Study Pregnant Women

Characteristics	Category	n	%
The duration of the marriage	<5 years	136	54.4
	5-10 years	89	35.6
	>10 years	25	10
Birthplace	Town	186	74.4
	Village	64	25.6
Education status	Illiterate and primary education	11	4.4
	Middle school	8	3.2
	Diploma	9	36
	Tertiary education	141	56.4
Economic status	Poor	12	4.8
	Moderate	102	40.8
	High	136	54.4
Pregnancy status	Intended	214	85.6
	Unintended	36	14.4
Month of pregnancy	The first trimester	69	27.6
	The second trimester	83	33.2
	The third trimester	98	39.2
Timing of pregnancy	Nulliparous	161	64.6
	Multiparous	89	35.6
Exercise	Yes	143	57.2
	No	107	42.8
Abortion history	Yes	50	20
	No	200	80
Taking medication during pregnancy	Yes	53	21.2
	No	197	78.8
Pica*	Yes	101	40.4
	No	149	59.6
Husband's support	Yes	239	95.6
	No	4.4	4.4
BMI	25≤	48	19.2
	≥25	202	80.8
Body image concern	Low	190	76
	Moderate	57	22.8
	High	3	1.2

Notes: BMI = Body Mass Index, *Pica = Eating disorder characterized by eating nonnutritive, nonfood substances over at least one month by pregnant women.

Table 2. The Mean ± SD of Dimensions of Body Image Concern and Quality of Life in Pregnant Women

Scale	Dimension	Mean ± SD
Quality of life	Physical functioning	56.30 ± 35.46
	Role-limitation due to physical problems	50.14 ± 23.70
	Role-limitation due to emotional problems	61.75 ± 23.89
	Fatigue	79.50 ± 67.22
	Vitality	62.92 ± 26.95
	Social functioning	62.70 ± 26.24
	Pain	60.02 ± 28.03
	General health	67.10 ± 26.13
	The total score of QOL	54.62 ± 15.71
Body image	Body dissatisfaction	16.18 ± 5.04
	The interference of one's concern with the appearance in social functioning	15.58 ± 5.67
	The total score of body image	31.77 ± 9.86

Notes: QOL = Quality of life, SD = Standard Deviation

Table 3. The Association between Body Image and Quality of Life with Sociodemographic and Pregnancy-related Variables

Variable	Category	Body Image		Quality of Life	
		Mean ± SD	p-value	Mean ± SD	p-value
The duration of the marriage	<5 years	31.34±9.78	0.493	64.31±15.02	0.100
	5-10 years	32.74±10.15		59.73±16.37	
	>10 years	30.68±9.32		62.94±16.16	
Birthplace	Town	31.88±9.58	0.773	61.98±15.80	0.336
	Village	31.46±9.96		64.17±15.45	
Education status	Illiterate and primary education	30.72±10.53	0.139	64.63±18.07	0.034
	Middle school	34.75±11.10		61.56±8.23	
	Diploma	33.47±11.59		58.73±5.34	
	Tertiary education	30.60±8.35		65.79±15.73	
Economic status	Poor	27.41±7.71	0.001	65.34±9.88	0.214
	Moderate	34.38±11.34		60.47±15.10	
	High	30.20±8.30		63.85±16.47	
Pregnancy status	Intended	31.14±9.73	0.013	62.50±16.02	0.928
	Unintended	35.55±9.90		62.76±13.96	
Month of pregnancy	The first trimester	32.04±10.33	0.783	63.55±15.14	0.238
	The second trimester	31.15±8.67		64.16±16.43	
	The third trimester	32.11±10.52		60.46±51.71	
Timing of pregnancy	Nulliparous	31.76±10.32	0.979	62.59±15.85	0.973
	Multiparous	31.79±9.02		62.66±15.77	
Exercise	Yes	31.46±9.44	0.606	62.28±15.51	0.765
	No	32.14±10.43		62.89±16.05	
Abortion history	Yes	32.44±9.92	0.596	59.91±15.59	0.186
	No	31.61±9.86		63.20±15.71	
Disease during pregnancy	Yes	32.16±10.00	0.032	62.25±15.96	0.314
	No	27.10±6.53		62.04±12.14	
Taking medication during pregnancy	Yes	34.20 ±11	0.043	59.02±16.48	0.066
	No	31.12±9.36		63.49±15.40	
Husband's support	Yes	31.76±9.92	0.964	62.47±15.95	0.739
	No	31.90±8.76		64.09±9.54	
BMI	≤25	29.10±6.74	0.037	64.07±16.43	0.45
	≥25	32.41±10.38		62.18±15.56	

Notes: QOL = Quality of Life, BMI = Body Mass Index, SD = Standard Deviation

Table 4. Correlation between Body Image Concern and Quality of Life in Pregnant Women

		Physical functioning	Role-limitation due to physical problems	Role-limitation due to emotional problems	Fatigue	Vitality	Social functioning	Pain	General health	The total score of QOL
Body dissatisfaction	r	-0.036	-0.112	-0.217	-0.239	-0.343	-0.272	-0.071	-0.252	-0.314
	p-value	0.573	0.077	0.001	0.001	0.001	0.001	0.260	0.001	0.001
The interference of one's concern with the appearance in social functioning	r	-0.050	-0.046	-0.165	-0.212	-0.250	-0.167	-0.145	-0.253	-0.265
	p-value	0.468	0.009	0.001	0.001	0.008	0.022	0.001	0.001	0.001
The total score of body image	r	-0.047	-0.087	-0.206	-0.244	-0.319	-0.235	-0.120	-0.274	-0.313
	p-value	0.459	0.187	0.001	0.001	0.001	0.001	0.059	0.001	0.001

Notes: QOL = Quality of Life, r = Pearson correlation

0.039), those with the chronic disease during pregnancy (p-value = 0.032), those taking medication during pregnancy (p-value = 0.043), those with BMI more than 25 (p-value = 0.035), and those with social pressure (p-value = 0.008). Besides, the quality of life was higher among those with a higher education level (p-value = 0.034).

Table 4 represents the correlation between body image concern and quality of life in pregnant women. A negative and significant correlation was found between

Table 5. Predictors of Body Image Concern and Quality of Life among Pregnant Women

Outcome	Variable	Unstandardized Coefficient	SE	p-value	95% CI	Standardized Coefficient
BICI	Vitality	-0.081	0.023	0.001	-0.126 — -0.035	-0.220
	BMI	0.464	0.159	0.004	0.150 — 0.778	0.171
	General health	-0.067	0.023	0.005	-0.113 — -0.021	-0.177
	Pregnancy type	3.590	1.629	0.029	0.380 — 6.799	0.128
SF-12	Dysmorphic	-0.980	0.188	0.001	-1.350 — -0.579	-0.610

Notes: BMI = Body Mass Index, BICI = Body Image Concern Inventory, SF-12 = 12-Item Short Form Survey, SE = Standard Error, CI = Confidence Interval

body image, body dissatisfaction, interference of one's concern with appearance in social functioning, and role-limitation due to emotional problems (r = 0.206, p-value = 0.001), fatigue (r = -0.244, p-value = 0.001), vitality (r = 0.319, p-value = 0.001), social functioning (r = 0.235, p-value = 0.001), general health (r = 0.274, p-value = 0.001), and the total score of quality of life (r = -0.313, p-value = 0.001). Furthermore, a significant and negative correlation was observed between the interference of one's concern with the appearance in social functioning and pain (r = 0.145, p-value = 0.022) in the quality of life scale.

Multivariate linear regression was carried out to assess pregnant women's body image and quality of life (Table 5). The most important predictors of body image were vitality, BMI, general health, and unintended pregnancy, respectively. This result means that a decline in quality of life in the dimensions of vitality, general health, high BMI during pregnancy, and unintended pregnancy was associated with an increase in the probability of body image disturbances in pregnant women. Furthermore, body image dissatisfaction became the most important predictor of quality of life. A higher score of body image dissatisfaction was associated with lower quality of life in pregnant women.

Discussion

The objective of this study was to examine the relationship between body image and quality of life and associated factors with these in pregnant women. Although the variables of body image and quality of life in pregnant women have been investigated in previous studies, based on literature review, no study has examined the relationship of these two concepts in pregnant women in Iran; hence, the finding of this study was unique.

In this study, pregnant women rated their quality of life as moderate and their body image concern as low. In previous studies, quality of life in pregnant women was found at a moderate level.[29,30] According to the results of this study, the most important predictor of quality of life among pregnant women was body image. Also, a negative and significant association was observed between body image and quality of life. Consistent with the present study, which found a positive and significant association between mindful eating and quality of life. The study also found a negative and significant association between body image, eating behaviors, and quality of life among married and fat women.[31] Rezaei, *et al.*,[24] have indicated that pregnancy can affect women's body image and reduce their quality of life. Besides, in a study by Türk KE, *et al.*,[32] Gardikiotis, *et al.*,[33] and Bagheri, *et al.*,[34] the body image and QOL of women who had mastectomy were negatively affected. These studies also showed that women who had mastectomy experienced stress, persistent psychological distress, and body image disturbance.[32-34]

In this study, pregnant women reported low body image concerns. Based on the study by Doncumbe, *et al.*,[35] body image was reasonably stable across pregnancy. Women who started with more significant body concerns maintained them over time, consistent with the results of this study.[35] Also, Loth, *et al.*,[36] demonstrated that pregnant women experienced body satisfaction despite weight gain. However, body image disturbance and body image dissatisfaction are common during pregnancy, according to the previous studies.[10,17,37]

The results of this study revealed that BMI was the most significant predictor of pregnant women's body image and body dissatisfaction, meaning that those with higher BMI had greater body image disturbance and body dissatisfaction. Similarly, other related studies have shown that pregnant women experience body image disturbance and body dissatisfaction due to mental and physical changes and a marked increase in body weight and fat mass.[38-40] Erkaya, *et al.*,[41] indicated a positive relationship between BMI and how pregnant women perceive their body and body image. Besides, Boscaglia, *et al.*,[42] demonstrated that pregnant women had positive evaluations of their body image and body satisfaction despite the weight gain during pregnancy and falling further from the cultural ideal of beauty. Senobari, *et al.*,[43] showed no association between BMI, body image concern, and sexual functioning. Nevertheless, in this study, BMI was one of the disturbance factors in body image

and body dissatisfaction in pregnant women. The inconsistency of these findings may be attributed to the different methods (study designs, cultural and social factors, sampling place, and the age of pregnant participants) applied in these studies.

According to bivariate analyses, there was a positive and significant association between economic status and pregnant women's body image. In contrast, according to regression analyses, economic status was not a predictor of body image in pregnant women. These results differed from the previous studies. For example, studies by Clark, *et al.*, You, *et al.*, and Sutherland, *et al.*, showed a significant association between economic status and body image, meaning that those with better economic status have more facilities for better nutrition. Therefore, women with better economic status pay more attention to their appearance.[44-46] In contrast, Kops, *et al.*,[47] showed that an increase in economic status leads to more significant body image disturbance. Similarly, Nikniaz, *et al.,* and Inanir, *et al.*, showed no significant association between body image and economic status.[4,48] Disparity between the results of studies may be linked to contextual sociocultural and methodological factors.

This study findings also revealed that pregnancy status was one of the predictors of participants' body image. It refers to the understanding that pregnant women with an unintended pregnancy may have a higher likelihood of experiencing body image disturbance than those with an intended pregnancy. Garrusi, *et al.*,[49] suggested that pregnant women with an unintended pregnancy had a lower level of appearance satisfaction. However, in a study by Rahmanian, *et al.*,[10] no significant association was found between body image and pregnancy status. Body image dissatisfaction among pregnant women appears to be due to psychological and mental problems, pregnancy concerns, mental conflict, lack of self-care, and lack of husband's support.[10]

Although this study provided valuable findings on body image and quality of life, there are still limitations. First, data were collected using self-reported questionnaires, leading to a reporting bias. Second, information on weight and height were self-reported by participants, which may have affected the study's results. Therefore, further studies will need to be performed to address these limitations. Furthermore, this study was conducted in a western city of Iran, and these results may not be generalizable to other geographical areas. Hence, it is recommended that further studies be carried out in different parts of the country with different beliefs and cultures.

Conclusion

In this study, pregnant women rated their quality of life as moderate and their body image concern as low. Moreover, the predictors of body image concern were vitality, BMI, general health, and intended pregnancy. Body image score was found to be the most important predictor of quality of life in pregnant women. Identifying risk factors influencing the quality of life and body image among pregnant women can assist the prenatal care team and to conduct required interventions and planning for retaining the risk group's health.

Abbreviations

BICI: Body Image Concern Inventory; BMI: Body Mass Index; QOL: Quality of life; WHO: World Health Organization; HRQOL: Health-Related Quality of life; ANOVA: Analysis of Variance; SD: Standard Deviation; BICI: Body Image Concern Inventory; SF-12: 12-Item Short Form Survey.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of Ilam University of Medical Sciences after approving in the Faculty Research council (Reference NO: IR, MEDILAM, REC,1397,142). All pregnant women in this study were participated voluntarily and completed the informed consent form.

Competing Interest

The author declares 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 data are not publicly available owing to their containing information that could compromise the study's participant privacy and consent. However, the data supporting this study's results were made available by the corresponding author upon reasonable request.

Authors' Contribution

AA and ZRF were involved in conceptualizing the study design and contributed to data collection. YV analyzed the data. All of the authors were involved in manuscript writing and final approval of the manuscript.

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The Estimation of Excess Mortality during the COVID-19 Pandemic in Jakarta, Indonesia

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Abstract

Indonesia is among the countries affected by the coronavirus disease 2019 (COVID-19) pandemic, and DKI Jakarta Province recorded the highest number of deaths. This study aimed to analyze the excess mortality across five administrative cities in Jakarta stratified by gender to assess the pandemic impact on mortality. The monthly mortality data from January 2018 to December 2020 was obtained through government sources. This data helped to measure excess mortality by estimating the baseline mortality had the COVID-19 pandemic not occurred. The analysis used a linear mixed model because of its ease and flexibility in forecasting subject-specific mortality. The results showed 13,507 or 35% excess deaths in Jakarta [95% CI: 11,636 to 15,236] between June and December 2020. The excess numbers were found relatively higher among men than women. Furthermore, Jakarta has underreported the COVID-19 deaths at least seven times higher than the reported number of confirmed deaths.

Keywords: baseline mortality, COVID-19, excess mortality, linear mixed model, subject-specific

Introduction

The coronavirus disease 2019 (COVID-19) caused global havoc. This pandemic started in Wuhan City, China, on December 31, 2019 and continued to spread worldwide. Indonesia was also affected by the rising COVID-19 cases, which announced the first case of COVID-19 at the beginning of March 2020. The number of positive cases reached 743,198, with 22,138 deaths on December 31, 2020.[1] Additionally, *Daerah Khusus Ibukota* (DKI) Jakarta was the most affected province, with 25% positive cases and 15% deaths nationwide. The number of reported cases was affected by test coverage, and some infected patients died without being tested or showing a false negative. Therefore, the test-confirmed deaths underestimated the actual death toll from the pandemic, specifically in countries such as Indonesia with low testing capacities.[2]

Beyond the deaths caused by the COVID-19 disease itself, the pandemic could have an indirect effect that can potentially increase the number of deaths caused by second mortality, such as delayed health care access and resources diverted towards the situation. The lockdown or large-scale social restrictions (LSRR)/*Pembatasan Sosial Berskala Besar* (PSBB) by DKI Jakarta's Provincial Government may also affect mortality rates. In order to understand the impact of the pandemic, measuring excess mortality is essential as the pandemic is causing more deaths than expected in a given period. The mortality numbers due to COVID-19 may be under-reported and also may be indirectly responsible for additional deaths.

The excess mortality estimations follow various perfectly curated and suitable mathematical models for effective results. However, modeling is not straightforward for estimating the deaths due to different factors that need to be considered for accurate results.[3] Time series analysis-based prediction model is generally adopted by exploiting the serial correlation in the historical mortality data,[4,5] but this approach relies on a solid assumption such as stationarity. Another approach is a linear mixed model, offering the flexibility to model longitudinal data with the inclusion of mean and variability structures.[6] The estimation model flexibility is crucial due to the dynamic variations in the coronavirus spread. The variations should be understood and integrated into the model on a real-time basis for effective balancing roles.

The linear mixed model has been demonstrated to outperform the commonly used monthly or weekly po-

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pulation averaging to forecast mortality at the baseline level.[7] Therefore, the objective of this study was to utilize a linear mixed model to forecast the subject-specific baseline mortality, obtaining excess deaths estimation using the public forum's data. Specific analyses by gender and administrative cities were also covered in more detail. The analysis also fixed the reasons for the excess deaths and pinpointed the areas that could improve the system. Also, it would ensure that the readers can get the complete estimation figures and be vigilant in anticipating the upcoming challenges effectively.

Method

The all-cause mortality data in previous years were retrieved from Jakarta's Open Data,[8] providing the number of deaths by gender for five administrative cities in DKI Jakarta Province (South Jakarta, East Jakarta, Central Jakarta, West Jakarta, and North Jakarta). Due to the limitation of data sources, the analysis was based on monthly data from January 2018 to December 2020. The number of deaths reported as COVID-19 was obtained from the Department of Communication, Informatics, and Statistics of DKI Jakarta Province,[1] on a monthly basis from March 2020, when COVID-19 was officially declared to have transmitted in Indonesia, to December 2020.

The statistical analysis used a similar approach studied by Verbeeck *et al.*,[7] The monthly mortality data from January 2018 to February 2020 was modeled using a linear mixed model. Only the first two months of 2020 were considered in building the model since the pandemic was confirmed to spread in March 2020, and the remaining months in 2020 were forecasted. The model was expressed in Formula 1 where $\varepsilon_{tj} \sim N(0,\sigma^2)$, $b_j \sim N(0,D)$ and ε_{tj} and b_j were mutually independent. The response variable y_{tj} denoted mortality data for a given administrative city j in month t, β_0 and β_1 were the common intercepts and b_j was the administrative city-specific random intercepts. To account for the time effect, a function of time t, f(t), was considered in the model. Three different functions, f(t), were used, e.g., (1) a linear term for time, (2) a cubic smoothing spline to describe monthly mortality variations,[9] and (3) yearly Fourier series,[7] to account for cyclical pattern that might present in the data. If necessary, additional random or fixed effects can be easily included in the linear mixed model. Model parameters estimation used restricted maximum likelihood (REML) as it showed to perform better by removing finite-sample bias than ML estimators (Formula 2).[10]

The model's appropriateness was examined using several statistics. The likelihood ratio test compared two nested models by calculating and comparing likelihoods for the two models, measured as the deviance.[11,12] Information criteria such as Akaike Information Criteria

$$y_{tj} = \begin{cases} \beta_0 + b_j + f(t) + \varepsilon_{tj} & , if\ male \\ \beta_1 + b_j + f(t) + \varepsilon_{tj} & , if\ female \end{cases}$$

Formula 1. Linear Mixed Model of Monthly Mortality Data from Januari 2018 - February 2020

$$RMSE\% = \frac{\frac{1}{n}\sqrt{\Sigma(y_{tj} - \hat{y}_{tj})^2}}{\frac{1}{n}\Sigma y_{tj}} \times 100$$

Formula 2. Model Evaluation with Root Mean Square Error Percentage (RMSE%)[10]

(AIC) and Bayesian Information Criteria (BIC) were alternative model selection procedures by allowing nonnested models comparison. It used deviance to measure fit by adding a penalization for a more complex model.[13] The root means square error percentage (RMSE%) was also considered to evaluate the forecasting accuracy of the models.[7]

The data were first explored to gain insight into the mortality trend over time and determine appropriate time functions in the linear mixed model. Formula 1 was built using training data, which consisted of monthly mortality data from January 2018 to February 2020. The fitted model was then used to estimate the expected mortality in the absence of COVID-19 based on the pattern of all-cause mortality in prior years through forecasting from March to December 2020. The excess number was computed by subtracting observed all-cause mortality (total death) in the same forecasted period from the corresponding expected mortality in each administrative city across gender. The total excess number for DKI Jakarta Province (from now on referred to as "Jakarta") was calculated by combining the excess of five administrative cities numbers.

It should be noted that the accumulated total excess mortality in 2020 was based on the calculation from June 2020. The mortality data before June 2020 appeared to be outliers as they showed unusual behavior with a substantial decrease, particularly in March 2020 (Formula 1). This situation was caused by the implemented lockdown and LSRR for the first time, according to Government Regulation No. 21 of 2020. It affected people staying at home and only being able to report death cases in the following months. Therefore, the excess calculation excluded outlier months to improve forecast accuracy.

Similarly, the fraction of death (% excess) was computed for each administrative city across gender. The excess mortality ratio to the reported COVID-19 deaths was also calculated as an undercount of COVID-19

deaths.[14] To account for uncertainty in the excess estimates, the empirical 95% confidence interval was calculated using a parametric bootstrap approach. Specifically, 1,000 bootstrap samples (y^*_{tj}) were generated from a random sample $\varepsilon^*_{tj} \sim N(0,\sigma^2)$ and $b^*_j \sim N(0,D)$. A linear mixed model was fitted to the bootstrap data for each simulation, and the predictions for all-cause mortality in the absence of COVID-19 were derived. Finally, the crude excess death rates (excess deaths divided by population multiplied by 100,000 people,[15]) were calculated in five administrative cities of DKI Jakarta Province, separately in men and women. The data were analyzed in RStudio 4.0.3 using lmer4 package,[16] to fit linear mixed model and spline package,[17] to perform cubic smoothing splines.

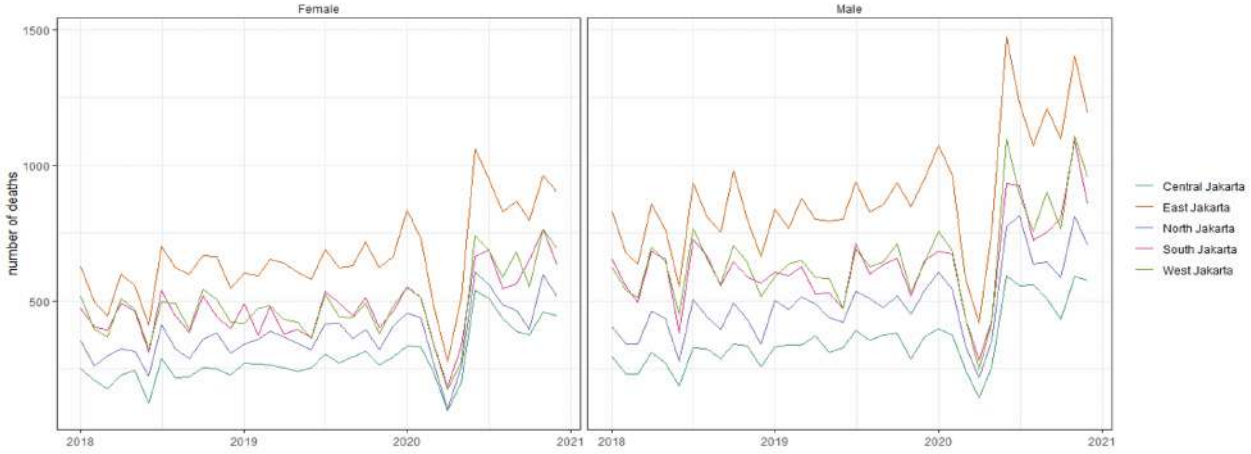

Figure 1. Mortality Trend from 2018 to 2020 by Gender and Administrative Cities in Jakarta

Table 1. Estimation of Excess Death Associated with COVID-19 Pandemic (95% Confidence Interval) from June-December 2020

	Total Deaths	Expected Death	Excess Deaths (a)	% Excess	Total Reported COVID-19 Deaths (b)	Difference between (a) and (b)	Undercount of COVID-19 Deaths
Total							
Central Jakarta	6,964	4,898	2,052 (1,648 to 2,455)	42%	240	1,812 (1,408 to 2,215)	8.55
East Jakarta	15,045	10,881	4,182 (3,779 to 4,602)	39%	561	3,621 (3,218 to 4,041)	7.45
North Jakarta	8,599	6,510	2,104 (1,671 to 2,527)	32%	250	1,854 (1,421 to 2,277)	8.42
South Jakarta	10,591	8,194	2,380 (1,959 to 2,821)	29%	419	1,961 (1,540 to 2,402)	5.68
West Jakarta	11,176	8,382	2,789 (2,358 to 3,208)	33%	411	2,378 (1,947 to 2,797)	6.79
Jakarta	52,375	38,865	13,507 (11,636 to 15,236)	35%	1,881	11,626 (9,755 to 13,355)	7.18
Male							
Central Jakarta	3,815	2,692	1,116 (878 to 1,344)	41%	129	987 (749 to 1,215)	8.65
East Jakarta	8,680	6,194	2,505 (2,269 to 2,748)	41%	329	2,176 (1,940 to 2,419)	7.61
North Jakarta	4,978	3,632	1,354 (1,111 to 1,577)	37%	143	1,211 (968 to 1,434)	9.47
South Jakarta	6,085	4,609	1,459 (1,223 to 1,686)	32%	255	1,204 (968 to 1,431)	5.72
West Jakarta	6,475	4,715	1,746 (1,511 to 1,985)	37%	248	1,498 (1,263 to 1,737)	7.04
Jakarta	30,033	21,842	8,180 (7,229 to 9,102)	37%	1,104	7,076 (6,125 to 7,998)	7.41
Female							
Central Jakarta	3,149	2,206	936 (716 to 1,167)	42%	111	825 (605 to 1056)	8.43
East Jakarta	6,365	4,687	1,677 (1,448 to 1,913)	36%	232	1,445 (1,216 to 1,681)	7.23
North Jakarta	3,621	2,878	750 (529 to 968)	26%	107	643 (422 to 861)	7.01
South Jakarta	4,506	3,585	921 (706 to 1,149)	26%	164	757 (542 to 985)	5.62
West Jakarta	4,701	3,666	1,043 (822 to 1,257)	29%	163	880 (659 to 1094)	6.40
Jakarta	22,342	17,022	5,327 (4,371 to 6,251)	31%	777	4,550 (3,594 to 5,474)	6.86

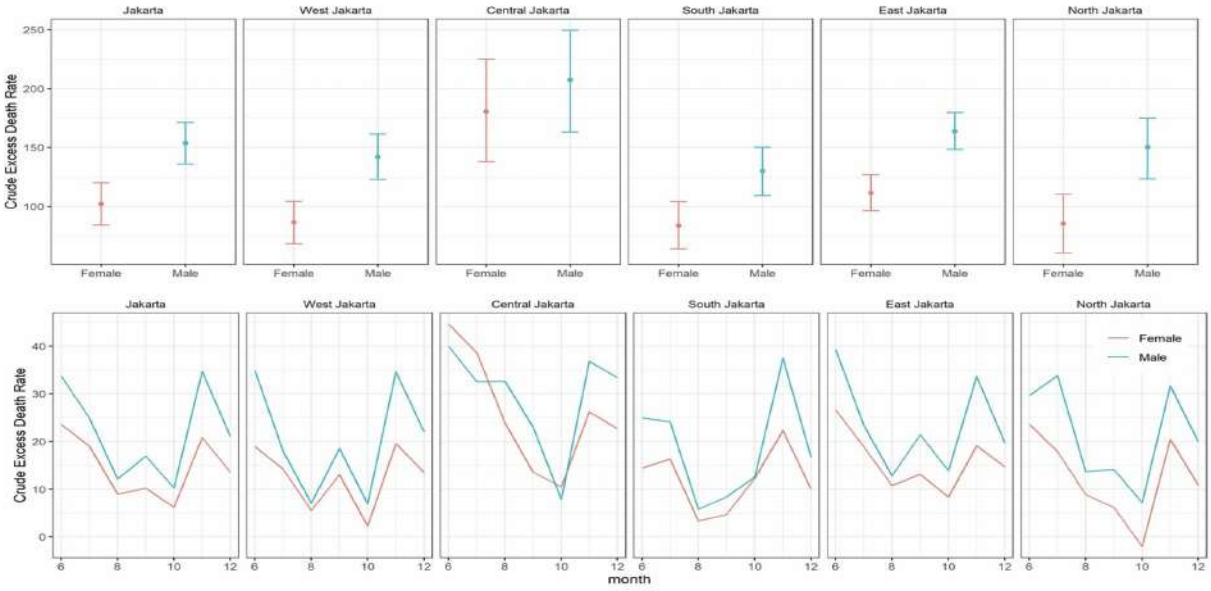

Figure 2. Accumulated Crude Excess Death Rate (Top Panel) and Trend in Crude Excess Death Rate from June-December 2020 (Bottom Panel)

Results

All-cause mortality during the study period displayed fluctuating upward trend (Figure 1). The five administrative cities had similar mortality trends over the years, with notes that East Jakarta showed more deaths and Central Jakarta showed the lowest. Additionally, mortality was generally higher among men than women. Different functions of time were adapted in the linear mixed models to account for time trend effects.

The linear mixed model with a linear term for time outperformed the other models, reporting the lowest BIC value and the lowest forecasting accuracy (AIC = 2723.3; BIC = 2747.7; %RMSE = 8.46). A linear mixed model with cubic smoothing splines with 5 degrees of freedom yielded AIC = 2732.1, BIC = 2760.0, and %RMSE = 8.56. The linear mixed model with yearly Fourier series had AIC = 2719.7; BIC = 2758.0, and %RMSE = 8.59. Adding additional random effects (such as random slope for time) to the model led to a singular fit, indicating the random-effects structure was too complex to be supported by data. Allowing both genders to have different evolution over time or including an interaction term between gender and time also did not improve the fitted model due to insignificant likelihood ratio test at 5% level (χ^2 (1) = 0.7502, p-value = 0.386). Additionally, the model's AIC and BIC statistics with interaction term were higher, e.g., 2724.6 and 2752.4, respectively, than without interaction.

From the period of June to December 2020, a total of 52,375 deaths were recorded in Jakarta, with estimated excess deaths of 13,507 (95% CI = 11,636 to 15,236) or approximately 35% higher than the expected baseline number when accounting for a linear time trend in the calculation (Table 1). East Jakarta had the highest absolute number of excesses, with an estimated increase of 4,182 (95% CI = 3,779 to 4,602). In terms of excess percentage, Central Jakarta had the highest increase with 42% than the number of expected deaths, despite having the lowest absolute number of excesses at 2,052 (95% CI = 1,648 to 2,455) than other administrative cities. Men consistently had a higher estimated number of excess deaths than women across administrative cities. They had an increase of 8,180 (95% CI = 7,229 to 9,102), corresponding to 37% increase. In contrast, the women had an increase of 5,327 (95% CI = 4,371 to 6,251), corresponding to 31% increase.

A total of 1,881 death cases due to COVID-19 were reported in Jakarta from June to December 2020. This number was then compared to the estimated excess deaths, as shown in Table 1. The results indicated that the number of excess deaths exceeded the official COVID-19 recorded deaths by Jakarta's Government by 11,626 (95% CI = 9,755 to 13,355). This was significantly higher among men (7,076; 95% CI = 6,125 to 7,998) than women (4,550; 95% CI = 3,594 to 5,474). Breakdown by administrative cities, East Jakarta, showed the largest difference at 3,621 (95% CI = 3,218 to 4,041) than the other four.

Jakarta experienced an undercount of COVID-19 deaths similar to most countries since the ratio was above one.[18] The ratio was higher among men at 7.41 than women at 6.86. Central and North Jakarta had the high-

est ratio above of the five administrative cities.[8] These large undercount ratios suggested that the number of COVID-19 deaths in Jakarta was inaccurate and more likely to have been significantly underreported.

Figure 2 shows the crude excess death rate (excess deaths divided by population multiplied by 100,000 people,[18]) in Jakarta and administrative cities, separately in men and women. It is evident from the plot that there is a significant difference in the excess death rate between men and women in Jakarta. The estimated crude excess death rate among men per 100,000 people was 154 (95% CI = 136–171), higher than women with 102 (95% CI = 84–120). Central Jakarta had the highest crude death rate but lacked a significant difference between men (207, 95% CI = 163–250) and women (180, 95% CI = 138–225).

The crude excess death rate trend between June and December 2020 by gender and administrative cities indicated similar risk trends across gender, but men had consistently higher rates than women. For Jakarta, there was a higher excess rate in June which decreased until October 2020 and increased in November 2020. It supported the reported number of COVID-19 transmissions in Jakarta, which increased at the beginning of November. The government then instructed to implement lockdown or LSRR, and there was a decreasing excess rate in the following month of December.

Discussion

Most studies measured mortality using time series models,[19-21] or methods of averaging the 5-year historical mortality data,[22,23] and a few utilized linear mixed models. The linear mixed model has the advantage over traditional analysis procedures, conducting simultaneous inferences for multiple outcomes by introducing random effects in the model.[24] This method gives forecast values with minor variance than the time series model.[7]

The result revealed an excess number of 13,507 deaths in overall Jakarta, which was far higher than the official record of 1,881 deaths related to COVID-19 in 2020. Stratified analysis by gender and administrative cities indicated an excess numbers variation. Men experienced higher excess mortality with a 37% increase from the expected baseline number, while women experienced a 31% increase. Other studies noted these discrepancies, indicating that most countries reported gender mortality inequality with higher excess among men than women.[19,25,26]

The excess to the reported COVID-19 death ratio revealed that Jakarta had an undercount ratio of 7.18. The data followed other countries' analysis as many had ratios above one.[14,27] However, various European and American countries had ratios below three. Countries like Belgium and France reported a ratio below one, indicating a very accurate report on COVID deaths,[28] and that all excess deaths were directly due to COVID-19.[29] The most extreme undercount ratios were above 30 in Uzbekistan, Nicaragua, and Tajikistan. However, the performance of the DKI Jakarta Provincial Government in handling this issue cannot be compared to other provinces and cities in Indonesia since no recent studies reported excess mortality in different cities.

A high undercount ratio above one suggested that Jakarta misclassified COVID-19 deaths.[27] This discrepancy was driven by inadequate testing or treatment access and the fact that diagnostic COVID-19 testing was not widely available at the pandemic's beginning. Indonesia's testing rate was 247 tests per million people since its first case in March 2020, placing in the second-lowest in Southeast Asia.[30] Therefore, the reported death numbers underestimated the accurate picture.

Secondary mortality caused a high undercount ratio in Jakarta. Indonesia was known for having a high prevalence of non-communicable diseases in previous years, such as hypertension, diabetes mellitus, chronic kidney disease, cancer, and stroke. When the pandemic took place, health care facilities were mainly diverted to provide services for the COVID-19 patients, limiting public (non-COVID patients) health systems access.[31] People were afraid of visiting the hospital to avoid the virus infection, delaying chronically ill patient's treatment and care. A cross-sectional study had similar findings identifying people's health services access barriers during the pandemic in Indonesia.[31] It indicated that fear of infection was one of the most influential barriers. The discrepancy was also due to poor contact tracing, resulting from the stigma around COVID-19 prompting expulsion fears in the communities. Hence, people provided incomplete data. Low testing rate and poor contact tracing caused incorrect identification of deaths attributed to COVID-19 and, at the same time, increased death rates.

Central Jakarta showed the most considerable rise in percentage of excess death at 42%, and the highest undercount of COVID-19 deaths at 8.55. A recent study identified Central Jakarta as the most affected administrative city in terms of distribution of COVID-19 cases.[32] This can be expected as it is among the busiest cities with high human mobility. In September 2020, the DKI Jakarta Provincial Government reported that Central Jakarta had more red zones than other administrative cities.[33]

Conclusion

This study assessed all-cause mortality in Jakarta during the COVID-19 pandemic from June to December 2020 across population subgroups. The excess deaths were estimated to be far higher than the official record related to COVID-19. The pandemic results increased

deaths, not only those who have died directly from COVID-19, but also those from all other causes. Limited diagnostic testing, weakened healthcare systems, and improper treatment for chronically ill patients caused the excess numbers. Men had higher excess mortality than women, and Central Jakarta appeared to be more severely affected in excess deaths than other administrative cities. The findings illustrated that the deaths estimation from all-cause mortality excess were more reliable than the government's official reported deaths. This study recommended that the provincial government monitor excess mortality as a critical tool to evaluate the effects of the ongoing pandemic.

Limitations and Recommendations

Government should implement nodal agencies to apply these data estimations to prepare and sync their arrangements with the requirements as and when needed. The analysis must be verified with the raw data figures to ensure the reliability of the data. The excess deaths data can also help handle the upcoming COVID-19 waves in a more prepared and efficient manner. Precise death estimations have various benefits, including the required doctor's engagement and daily medical supplies during the pandemic. These issues must be appropriately analyzed so that the correct trend of the pandemic can be gauged and there are no issues of unawareness or lack of knowledge with unavailable data.

This study had several important caveats. The preferred mortality data were collected by date of death for analysis. However, the public data only provided monthly data organized by the registration date, causing weekly or monthly spurious drops with public holidays, particularly during national lockdowns in March and April 2020. The problem of incomplete all-cause mortality data in the early COVID-19 pandemic may lead to underestimating the number of excesses that occurred in 2020. These issues can be resolved for better results when additional information and data related to the COVID-19 pandemic are released.

Despite the limitations, the estimated total excess mortality during a COVID-19 outbreak in Jakarta better perceives the mortality burden. The results confirmed that COVID-19 had a high mortality impact. In order to manage future outbreaks, this finding facilitated appropriate resource allocation for public health priorities. If COVID-19 is known to be the source of death, it must be correctly reported to make an accurate assessment of the pandemic's effects and properly direct public health response. Continuous monitoring of excess mortality will provide an important tool to evaluate the effects of an ongoing pandemic and enable better government management. Future work is required to understand the impact of age, socioeconomic status, and vaccination programs on excess mortality in Jakarta and in Indonesia. It will help people learn from the experience to mitigate any future issues.

Abbreviations

COVID-19: coronavirus disease 2019; DKI: *Daerah Khusus Ibukota*; LSRR: Large-Scale Social Restrictions; PSBB: *Pembatasan Sosial Berskala Besar*; REML: Restricted Maximum Likelihood; ML: Maximum Likelihood; AIC: Akaike Information Criteria; BIC: Bayesian Information Criteria; RMSE%: Root Means Square Error Percentage; CI: Confidence Interval.

Ethics Approval and Consent to Participate

Not applicable.

Competing Interest

The author declares 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 dataset is publicly available at Open Data Jakarta and the Department of Communication, Informatics, and Statistics of DKI Jakarta Province.

Authors' Contribution

MYW is the only contributor to data collection, statistical analysis, and article writing.

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The Determinants of COVID-19 Vaccine Acceptance in Sumatra

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Abstract

In light of the current coronavirus disease 2019 (COVID-19) vaccination programs being implemented worldwide, this study aimed to evaluate the COVID-19 vaccine acceptance survey in Indonesia conducted by the World Health Organization (WHO), the Ministry of Health of the Republic of Indonesia, the National Immunization Technical Advisory Group (NITAG), and the United Nations Children's Fund (UNICEF), published in November 2020. It was found that Sumatra Island having lower COVID-19 vaccine acceptance rates, with Aceh Province displaying the lowest level of vaccine acceptance. Thus, a cross-sectional study was conducted, and a logistic regression analysis was used to identify the factors affecting COVID-19 vaccine acceptance. Out of 368 respondents who participated in the survey, 143 (38.9%) accepted the vaccine, and 225 (61.1%) refused it. Vaccine safety concerns constituted the most reported reason for refusal (43.6%). This study also found that province of residence and basic immunization status were determinants of COVID-19 vaccine acceptance in Sumatra. Concerns regarding vaccine safety might be the reason for the low level of vaccination in Sumatra. Increased education and encouragement from healthcare professionals and regional authority figures can alleviate public concerns and improve vaccine acceptance.

Keywords: COVID-19, determinants, vaccine

Introduction

The coronavirus disease 2019 (COVID-19) pandemic has impacted the lives of millions of people worldwide. In Indonesia, a cumulative total of 1,460,184 confirmed cases and 39,550 deaths have been reported to date.[1] As the number of COVID-19 cases continues to increase; nations have rapidly developed vaccines to be made readily available for health workers and the general population. Vaccination programs have been implemented globally to relieve the socioeconomic burden on the healthcare system. The Indonesian Government has taken numerous measures towards implementing of a COVID-19 vaccination program. On January 11, 2021, the National Agency of Drug and Food Control/*Badan Pengawas Obat dan Makanan* (BPOM) published an Emergency Use Authorization (EUA) for the COVID-19 vaccine CoronaVac developed by Sinovac Biotech.[2] On January 13, 2021, the President of the Republic of Indonesia, Joko Widodo, was the first Indonesian citizen to be vaccinated at the presidential palace, officially launching the COVID-19 vaccination program in Indonesia.[3] However, for the program to be successful, it is imperative to evaluate the public's perception and acceptance of the vaccine.

Several studies have explored the prevalence of COVID-19 vaccine acceptance and its determinants among various populations in different countries. The World Health Organization (WHO), together with the Indonesian Ministry of Health, the Indonesia Technical Advisory Group on Immunization (ITAGI), and the United Nations Children's Fund (UNICEF), made a comprehensive report on COVID-19 vaccine acceptance in Indonesia in 2020. The survey revealed that 65% of respondents were willing to accept the vaccine, 8% refused, and the remaining respondents expressed hesitancy.[4] However, this study did not elaborate on the factors that might have resulted in vaccine acceptance in each province. The survey was a descriptive study, while this study conducted an association analysis of the determinants specifically regarding the Sumatran population. Vaccine hesitancy, a delay in acceptance or refusal of vaccination regardless of its availability, is a

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barrier to achieving herd immunity.[5] The study reported that provinces in Sumatra were amongst those with lower COVID-19 vaccine acceptance rates, with Aceh having the lowest acceptance rate.[4] Previous studies also reported that the provinces in Sumatra had incomplete immunization coverage rates of more than 70% in eight of ten provinces.[6-8]

The survey also demonstrated that vaccine acceptance varied based on geographical regions and socioeconomic factors such as economic status, religious and cultural beliefs, gender, insurance availability, and several concerns regarding the vaccine.[4] Sociodemographic factors such as age, province, gender, and marital status were included as variables to stratify demographic factors on COVID-19 vaccine acceptance. Immunization status, religion, economic status, education, employment, healthcare worker status, and insurance ownership have been found to affect vaccine acceptance rates by previous studies.[4] Incomplete immunization status often reflects limited knowledge and awareness regarding immunization, impacting vaccine acceptance.[9] Religion was included as a variable due to concerns about whether the COVID-19 vaccine is considered halal (permissible), which may impact vaccine acceptance in the Indonesian population. Lower economic status, education, and unemployment have been correlated with lower vaccine acceptance rates.[10-12] Healthcare workers may have more comprehensive knowledge of COVID-19 and relatively high awareness of the importance of vaccination and may be more willing to accept the vaccine.[13-15] Insurance ownership, prior experience with COVID-19, knowledge of COVID-19 vaccine distribution by the government, and willingness to pay are also variables that could potentially impact vaccine acceptance.

Evaluating the various factors contributing to vaccine acceptance and hesitancy in each geographical location is essential. These were important because vaccine hesitancy is complicated and context-specific.[16] This study was conducted to evaluate the determinants of COVID-19 vaccine acceptance in Sumatra. The second aim of the study was to understand the underlying issues present and develop strategies to overcome them.

Method

A cross-sectional online survey was designed using Google Forms and distributed through WhatsApp, Line, and Instagram between January and February 2021. Study samples were collected from ten provinces in Sumatra using a purposive sampling strategy. Inclusion criteria were respondents who consented to participate and were older than ten years of age. Respondents who did not complete the questionnaire were excluded. A previous study showed that 67% of respondents demonstrated acceptance of a potential COVID-19 vaccine.[15]

$$n = \frac{Z\alpha^2\,(pq)}{d^2} = 339 \approx 350$$

Formula 1. Sample Size Estimation

Sample size was calculated using the formula as in Formula 1, where n is sample size, p = proportion, α = 0.05, $Z\alpha$ = 1.96, and d = 0.05.

After accounting for incomplete questionnaires and dropouts, the final optimal sample size was estimated to be 350 completed questionnaires. The questionnaire used in this study was a modified version of the WHO COVID-19 Vaccine Acceptance Survey in Indonesia questionnaire.[4] The possible responses for "occupation" were modified to "unemployed non-healthcare worker," "employed non-healthcare worker," and "healthcare worker," which would be grouped into employment (employed/unemployed). Healthcare workers grouped into healthcare worker/non-healthcare worker status during data analysis. As previous studies have demonstrated the positive impact of prior immunization on future vaccine acceptance, an additional question regarding previous immunization history was added to the questionnaire.[17-22]

Ten provinces in Sumatra were grouped into high and low immunization coverage categories based on WHO statements that a vaccine coverage of $\geq$ 80% is considered high.[23] Data from UNICEF's Sustainable Development Goals (SDG) Baseline Report on Children in Indonesia on immunization coverage of the third dose of diphtheria, pertussis, and tetanus (DPT3) vaccine was used.[24] Data on DPT3 rather than measles vaccine coverage was used because the national immunization coverage for DPT3 was lower and better reflected the immunization coverage in Sumatra. Provinces with low immunization coverage included Aceh, Jambi, North Sumatra, Riau, South Sumatra, and West Sumatra. Those with high immunization coverage included Bangka Belitung Islands, Bengkulu, Lampung, and Riau Islands. Religion was reported as either Muslim or non-Muslim because the majority of the population of Sumatra is Muslim.[25] Economic status was categorized as poor/aspiring middle-class and middle/upper class based on an average household monthly expense cutoff of IDR 4,800,000 (equivalent to US$ 328.23. according to the April 12, 2021 exchange rate).[26] Education was grouped into tertiary education and elementary and secondary education based on The Indonesian Law no. 20 of 2003 Concerning the National Education System.[27]

The data were analyzed using descriptive statistics. First, a cross-tabulation analysis was performed to evaluate the participants' response to vaccine acceptance

Table 1. Sociodemographic Characteristics

Variable	Category	n	%
Age	<25 years	121	32.9
	≥25 years	247	67.1
Province	Provinces with low immunization coverage (Aceh, Jambi, North Sumatra, Riau, South Sumatra, West Sumatra)	244	66.3
	Provinces with high immunization coverage (Bangka Belitung Islands, Bengkulu, Lampung, Riau Islands)	124	33.7
Gender	Females	135	36.7
	Males	233	63.3
Marital status	Unmarried (single, divorced, or widowed)	166	45.1
	Married	202	54.9
Basic immunization	Incomplete	131	35.6
	Complete	237	64.4
Religion	Non-Muslim	134	36.4
	Muslim	234	63.6
Economic status	Poor/aspiring middle-class	283	76.9
	Middle/upper class	85	23.1
Education	Elementary and secondary education	208	56.5
	Tertiary Education	160	43.5
Employment	Unemployed	14	3.8
	Employed	354	96.2
Healthcare worker	Non-healthcare worker	334	90.8
	Healthcare worker	34	9.2
Insurance ownership	No Insurance	33	9
	Owns insurance	335	91
Experience with COVID-19: Have you ever been infected with COVID-19, or do you know someone close to you who has been infected with COVID-19?	No/not sure	281	76.4
	Yes	87	23.6
Do you know that the Government of the Republic of Indonesia has planned to provide the COVID-19 vaccine?	No	37	10.1
	Yes	331	89.9
Willingness to pay: Are you willing to pay for the COVID-19 vaccine?	Not willing/not sure	247	67.1
	Willing	121	32.9

concerning each independent variable. A bivariate analysis evaluated the associations between each independent variable and vaccine acceptance separately. Then, independent variables with a p-value≤0.25 and independent variables theoretically associated with vaccine acceptance were included in the multivariate analysis. For the multivariate analysis, the model was analyzed for confounding variables and potential interactions between the independent variables. The final logistic regression model was used to identify COVID-19 vaccine acceptance determinants in Sumatra. All data analyses were performed using SPSS software (IBM Corp., released 2020, IBM SPSS Statistics for Macintosh, version 27.0, Armonk, NY).

Results

A total of 368 respondents provided consent and completed the survey (Table 1). The majority (67.1%) of respondents were 25 years or older, and 66.3% were from provinces with low immunization coverage. More male respondents than female ones; 54.9% were married, and 64.4% received complete basic immunization. For the rest of the sociodemographic variables, 63.6% were Muslim, 76.9% belonged to the poor/aspiring middle-class category, 43.5% received tertiary education, 96.2% were employed, 90.8% were non-healthcare workers, and 91% owned health insurance. Concerns regarding vaccine safety constituted the most reported reason for refusal (43.6%), followed by side effects and efficacy (Table 2).

Table 2. Reasons for Vaccine Refusal

Reasons	(n = 225)	%
Concerns about the vaccine's safety	98	43.6
Concerns about the vaccine side effects	57	25.3
Concerns about the vaccine's efficacy	36	16.0
Other unspecified reason	11	4.9
Lack of trust	9	4.0
Unsure if a family will accept the vaccine	5	2.2
Religious beliefs	4	1.8
Comorbidities	3	1.3
Lack of knowledge of the vaccine	2	0.9

Cross-tabulation and bivariate analysis was done between the independent variables and vaccine acceptance (Table 3). Out of 368 respondents, 143 (38.9%) respondents answered "yes" to receiving the

Table 3. Cross-tabulation and Bivariate Analysis

Variable	Category	Willingness to Receive the Vaccine		p-value	Exp(B)	95% CI for Exp(B)	
		No	Yes				
		(n = 225) (%)	(n = 143) (%)			Lower	Upper
Age	<25 years	63 (52.1)	58 (47.9)	0.013	1.755	1.127	2.732
	≥25 years	162 (65.6)	85 (34.4)	Ref			
Province	Provinces with high immunization coverage (Bangka Belitung Islands, Bengkulu, Lampung, Riau Islands)	67 (54.0)	57 (46.0)	0.047	1.563	1.007	2.427
	Provinces with low immunization coverage (Aceh, Jambi, North Sumatra, Riau, South Sumatra, West Sumatra)	158 (64.8)	86 (35.2)	Ref			
Gender	Females	80 (59.3)	55 (40.7)	0.573	1.133	0.734	1.748
	Males	145 (62.2)	88 (37.8)	Ref			
Marital status	Unmarried (single, divorced, or widowed)	90 (54.2)	76 (45.8)	0.014	1.701	1.114	2.598
	Married	135 (66.8)	67 (33.2)	Ref			
Basic immunization	Complete	131 (55.3)	106 (44.7)	0.002	2.056	1.3	3.252
	Incomplete	94 (71.8)	37 (28.2)	Ref			
Religion	Non-Muslim	70 (52.2)	64 (47.8)	0.008	1.794	1.162	2.769
	Muslim	155 (66.2)	79 (33.8)	Ref			
Economic status	Middle/upper class	45 (52.9)	40 (47.1)	0.078	1.553	0.952	2.535
	Poor/aspiring middle-class	180 (63.6)	103 (36.4)	Ref			
Education	Elementary and secondary education	121 (58.2)	87 (41.8)	0.183	1.335	0.872	2.044
	Tertiary education	104 (65.0)	56 (35.0)	Ref			
Employment	Employed	216 (61.0)	138 (39.0)	0.806	1.15	0.378	3.503
	Unemployed	9 (64.3)	5 (35.7)	Ref			
Healthcare worker	Healthcare worker	17 (50.0)	17 (50.0)	0.165	1.651	0.813	3.35
	Non-Healthcare worker	208 (62.3)	126 (37.7)	Ref			
Insurance ownership	Owns insurance	203 (60.6)	132 (39.4)	0.496	1.3	0.611	2.77
	No insurance	22 (66.7)	11 (33.3)	Ref			
Experience with COVID-19: Have you ever been infected with COVID-19, or do you know someone close to you who has been infected with COVID-19?	Yes	45 (51.7)	42 (48.3)	0.04	1.663	1.023	2.704
	No/Not sure	180 (64.1)	101 (35.9)	Ref			
Do you know that the government of the Republic of Indonesia has planned to provide the COVID-19 vaccine?	Yes	200 (60.4)	131 (39.6)	0.399	1.365	0.662	2.811
	No	25 (67.6)	12 (32.4)	Ref			
Willingness to pay: Are you willing to pay for the COVID-19 vaccine?	Willing	41 (33.9)	80 (66.1)	<0.001	5.699	3.552	9.144
	Not Willing/Not sure	184 (74.5)	63 (25.5)	Ref			

Note: CI = Confidence Interval

vaccine, and the remaining 225 (61.1%) respondents answered "no." The variables that demonstrated significant associations with vaccine acceptance were age, province, marital status, basic immunization, religion, willingness to pay, and experience with COVID-19 (p-value<0.05).

In the logistic regression analysis (Table 4), the authors included all variables from the bivariate analysis that were statistically significant (p-value<0.25), including age, province, marital status, basic immunization, religion, economic status, education, healthcare worker, willingness to pay, and experience with COVID-19. However, several studies on factors affecting vaccine acceptance have consistently shown that employment status is associated with vaccine acceptance;[28,29] therefore, employment status was added to the multivariate analysis. The authors removed all variables with a p-value>0.05 and did not alter other variables' odds ratio (OR) by more than 10%. Variables that were removed included employment status, marital status, healthcare worker, and experience with COVID-19. Confounding variables included age, religion, economic status, and education—willingness to pay significantly associated with age, province, and religion (p-value<0.05). Seven variables were associated with vaccine acceptance: age, province, basic immunization,

Table 4. Logistic Regression Analysis of Determinants of COVID-19 Vaccine Acceptance, Final Model

Variable	β	Sig. (p-value)	Exp(B)	95% CI for Exp(B)	
				Lower	Upper
Age (<25 years old)	-0.505	0.271	0.603	0.246	1.483
Province (High immunization coverage)	1.001	0.002	2.721	1.453	5.096
Basic immunization (Complete)	0.709	0.009	2.031	1.194	3.455
Religion (Muslim)	-0.745	0.114	0.475	0.189	1.196
Economic status (Poor/aspiring middle-class)	0.338	0.289	1.402	0.751	2.615
Education (Elementary and secondary education)	0.135	0.612	1.144	0.68	1.924
Willingness to pay (Willing)	0.691	0.26	1.995	0.599	6.639
Willingness to pay (Willing) by Age (<25 years old)	1.683	0.011	5.38	1.467	19.722
Willingness to pay (Willing) by Province (High immunization coverage)	-1.333	0.022	0.264	0.084	0.828
Willingness to pay (Willing) by Religion (Muslim)	1.954	0.006	7.058	1.755	28.381

Note: CI = Confidence Interval

religion, economic status, education, and willingness to pay. Province and basic immunization were significant determinants of COVID-19 vaccine acceptance (p-value<0.05). Respondents from provinces with high immunization coverage were 2.721 times more likely to accept COVID-19 vaccination than provinces with low immunization coverage (OR = 2.721; 95% confidence interval [CI] = 1.453–5.096; p-value = 0.002). Respondents with completed immunization history were 2.031 times more likely to accept COVID-19 vaccination compared to those with incomplete immunization history (OR = 2.031; 95% CI = 1.194-3.455; p-value = 0.009).

Discussion

Vaccination programs were developed as part of a global effort to achieve herd immunity. However, a certain threshold of vaccination must be achieved for success. Studies on COVID-19 vaccine acceptance have been conducted in various countries and population groups worldwide to identify existing barriers and develop evidence-based interventions to overcome them. This study evaluated the determinants of COVID-19 vaccine acceptance in Sumatra only. Overall, there was a low rate of COVID-19 vaccine acceptance in Sumatra, with only 38.9% of respondents being willing to accept the vaccine. This finding agreed with the WHO COVID-19 Vaccine Acceptance Survey results in Indonesia, showing that provinces in Sumatra had low vaccine acceptance rates.[4] Differences in acceptance rates between this study and the WHO survey may be due to the progression of the COVID-19 vaccination program concerning the time of data collection and difference in sample size. Previous studies on vaccine acceptance and immunization coverage in Sumatra have also demonstrated similar findings.[30-33] In this study, the province of residence and basic immunization status were significantly associated with COVID-19 vaccine acceptance.

The age was not associated to the vaccine acceptance. Previous systematic review found that sex was the demographic variables examined most frequently across the ten studies and there was no consistent association between these variables.[21] Education was also not associated to the vaccine acceptance. This was stated from previous study that there were no differences between developing and developed countries in term of vaccine acceptance.[19]

Vaccine acceptance was 2.721 times more likely in provinces with high immunization coverage than provinces with low immunization coverage (OR = 2.721; 95% CI = 1.453–5.096; p-value = 0.002). A possible reason for this is the presence of religious norms and beliefs in areas with low immunization coverage.[34,35] The majority of the population in Sumatra is Muslim, and the Islamic Shari'ah law may affect public acceptance towards vaccination due to its conservativism. In the past, vaccine acceptance has been a challenge due to fear that vaccines may contain animal-derived products, considered haram (forbidden) in Islamic law.[35,36] In 2001, the WHO issued a statement based on Islamic religious scholars' opinions that animal-derived products that have been transformed are considered halal for medical use.[35,36] The COVID-19 pandemic presents a similar situation in that concerns about the vaccine's halal status have impacted vaccine acceptance in the Indonesian population. For reassurance, the Indonesian Ulama Council/*Majelis Ulama Indonesia* (MUI) released a fatwa (pronouncement) declaring that the COVID-19 vaccine is halal for use.[37]

Respondents with complete immunization history were 2.031 times more likely to accept the vaccine than those with incomplete immunization (OR = 2.031; 95% CI = 1.194–3.455; p-value = 0.009). Previous studies have consistently proven the positive impact of prior vaccination on future vaccine acceptance.[19,22,38] A study in China reported that past influenza vaccination increased

COVID-19 vaccine acceptance by 1.43–2.51-fold.[22] A systematic review also reported that previous vaccination history had the most significant effect on accepting of a newly released vaccine during a pandemic.[22] Out of seven studies that evaluated previous vaccination and future vaccine acceptance, six reported ORs ranging from 1.27 to 5.03. Two studies reported that prior vaccination was one of the top three determinants of vaccine acceptance.[19,22,38]

Most respondents cited concerns on vaccine safety, side effects, and efficacy. The vaccination of the President of the Republic of Indonesia was broadcast on television to increase the public's trust in the vaccine. In Indonesia, the COVID-19 vaccine was distributed in four phases. This study conducted surveys from January to February 2021, during which the vaccination program in Indonesia had only just begun, and healthcare workers were the first to receive the vaccine. Because only healthcare workers had been vaccinated, the public may still have had uncertainties regarding the vaccine's safety. Additionally, constant media coverage may have increased salience among the public regarding the vaccine. This situation, along with a lack of knowledge and information,[39], may have hindered vaccine acceptance.

The result of this study can aid the government and healthcare systems in implementing effective vaccination strategies to improve vaccine acceptance in Sumatra. Sumatra's low vaccine acceptance rate is partly caused by conservatism and a history of vaccine refusal, as shown by incomplete immunization history. Therefore, measures should be taken to increase education and communicate vaccination to the general public in understandable, layperson's terms, especially regarding vaccine safety. Together with other sectors such as religious or political authority figures, the Ministry of Health should reach out to all population groups and educate them on the importance of vaccination. Lack of knowledge and understanding, together with misinformation and salience, results in a lack of confidence, uncertainty, and fear of the vaccine. Increasing public health education on the mechanics and benefits of vaccination may improve not only COVID-19 vaccination rates but overall immunization rates in the province of Sumatra. Implementing these measures will be one step closer to ensuring the public's confidence in the vaccine and improving vaccine acceptance rates.

This study is among the first to evaluate determinants of COVID-19 vaccine acceptance on an island of Indonesia. It could provide reliable data on participants' responses as this study used a questionnaire similar to the survey conducted by the WHO, the Indonesian Ministry of Health, NITAG, and UNICEF. This study also had no missing data, and the collected sample was fairly representative of the population of Sumatra. Most importantly, this could stratify data based on sociodemographic parameters and provincial regions to predict COVID-19 vaccine acceptance in Sumatra. This understanding of the current barriers to vaccine acceptance may help identify population groups that require further attention and develop effective immunization strategies within the COVID-19 vaccination program.

This study has several limitations. Because the study was cross-sectional, the results reflect respondents' attitudes at the time of data collection only. Respondents' attitudes may change over time. The authors also did not evaluate other factors such as risk perception and trust in the health system.[29,30,40] The sample only included 34 health workers, potentially producing biased results on whether health worker status affected vaccine acceptance. The sampling technique may also have led to selection bias. Respondents required a smartphone or computer and internet access to participate. Generalizability sample due to the exclusion of lower socioeconomic classes, those with a lack of access to technology, and illiterate individuals.

Conclusion and Recommendation

This study found that province with high communization coverage, previous complete basic immunization, and willingness to pay of vaccine were the determinants of vaccine acceptance in Sumatra region. Increasing public health education by healthcare workers and authority figures is a viable strategy to improve vaccine acceptance. Alleviating public concerns about the vaccine is one of strategy to increase vaccine acceptance.

Abbreviations

COVID-19: coronavirus disease 2019; WHO: World Health Organization; ITAGI: Indonesia Technical Advisory Group on Immunization; UNICEF: The United Nations Children's Fund; BPOM: *Badan Pengawas Obat dan Makanan*; EUA: Emergency Use Authorization; SDG: Sustainable Development Goals; DPT3: Third Dose of Diphtheria, Pertussis, and Tetanus; CI: Confidence Interval; OR: Odds Ratio; MUI: *Majelis Ulama Indonesia*.

Ethics Approval and Consent to Participate

Ethics approval was obtained from the Faculty of Medicine, Pelita Harapan University's Research Ethics Committee, approval number 085/K- LKJ/ETIK/II/2021.

Competing Interest

The authors declare that there are no significant competing financial, professional, or personal interests that might have affected the performance.

Availability of Data and Materials

The data are not publicly available as it contains information that could compromise the privacy of research participants.

Authors' Contribution

CS conceptualized the study, outlined the design, analyzed the data, and wrote the manuscript. AK, NPHL, and JIS validated the study, supervised and revised the final manuscript. VS provided statistical advice, supervised and revised the final manuscript. NLS, SAR, TDS, CM assisted in data collection, RSH, DAH, CJ, FW, BS, EM, JW, JJA, MI, MI, NKH assisted in research proposal development and data collection.

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The Development of a Work Stress Model for Air Traffic Controllers in Indonesia

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Abstract

The workload complexity experienced by and expected air traffic controllers (ATCs) causes psychological fatigue, engenders stressful conditions, and affects their quality of life. This study investigated the development of a model of psychological fatigue in ATCs in Indonesia, which affected their work stress levels and quality of life. This cross-sectional, three-month study focused on 185 ATCs randomly selected from six AirNavs based on strata. The results indicated a relationship between work duration (p-value = 0.033) and stress on ATCs; additionally, a relationship between work time and the opportunity to meet personal life needs (p-value = 0.007) were found. Feelings of tiredness among ATCs manifested as a 'thirsty throat' feeling, and in saturation measurements, no respondents had experienced hypoxia in the two months of observation. Structural equation modeling showed that psychological fatigue had no direct effect on the quality of life; however, it had an indirect and significant effect on work stress (p-value = 0.001). It can be concluded that the stress conditions experienced by the ATCs have a palpable effect on feelings of fatigue and quality of life.

Keywords: air traffic control, fatigue, psychological, quality of life, work stress

Introduction

Workers' fatigue is a significant problem in modern organizations. It also acts as a 'final signal' of the integration of waking time in a day and the workload that one carries out daily.[1,2] Theoretically, the onset of this condition is characterized by increased anxiety, memory loss, attenuations in work efficiency and vigilance, poor motivation, high variability in performance, and negligence.[3] It is challenging for employers to identify and respond to the signs of worker fatigue—not to mention psychological disorders stemming from it—which can lead to both weak work productivity and reduced quality of life.[4]

One profession that especially requires the maintenance of psychological health to ensure optimal work performance is an air traffic controller (ATC).[5] The ATC duties generate tension, especially during the critical decision-making process over aviation traffic control.[6-10] Given that 55% of worldwide aircraft accidents are caused by human error—and that this number is 60.71% in Indonesia, with ATCs accounting for 5% due to incidence (e.g., miscommunication),[11,12]—the importance of sound psychological health in this profession cannot be overstated.

The effect of psychological disturbance on ATCs is captivating because its amelioration is material to improving job performance. Furthermore, no study has concurrently examined ATCs in Indonesia and several AirNav branches (which have three strata) to identify the causes of work fatigue generally; this is concerting, considering that Indonesia has one of the busiest airports in Asia.[13] The International Air Transport Association (IATA) predicts that by 2036, Indonesia will become the world's fourth-largest air travel market and have an estimated 355 million passengers flying from and within the country in 2034. This predicted growth runs in tandem with Indonesia's promotion of airline-based tourism as something that is for everyone.[13-15]

When energy is depleted, individuals feel tired and sleepy, leading to severe stress conditions of fatigue. Likewise, most controllers experience mental fatigue due to the stress of tasks and responsibilities when making decisions that are important to flight safety, leading to psychological impairments. So, psychological fatigue among ATCs must be addressed everywhere as urgently as possible, especially in Indonesia, which is predicted to become one of the world's largest air travel hubs.[13] Therefore, this study aimed to develop a model of psychological fatigue to help ease ATC work stress, whi-

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ch impacted their quality of life and work performance.

Method

This was a cross-sectional study, and leveraged data from six AirNavs, selected on the basis of strata; those from the Main (Makassar Air Traffic Service Center /MATSC), Intermediate (AirNav Denpasar and AirNav Surabaya), and Pratama (AirNav Kupang, AirNav Lombok, and AirNav Bandung) branches. Data collection was carried out on six selected AirNav branches with the help of previously trained enumerators from their respective regions. Data were collected by interviewing each ATC about occupational stress. A questionnaire was measured feelings concerning work fatigue (*Kuesioner Alat Ukur Perasaan Kelelahan Kerja/*KAUPK2), and considering tensimeter, oximeter, and Quality of Life World Health Organization (QOL–WHO) measures. The authors validated and calibrated all instruments before undertaking the study.

The data was collected on individual identity (age, gender, and service years), health status (pulse, blood–oxygen levels, and blood pressure), productivity, work fatigue symptoms, and the ATC's quality of life. It was collected between January and June 2020 and performed sampling using proportional stratified random sampling. The total sample comprised 185 randomly selected ATCs.

The data was collected by interviewing each ATC and using occupational stress instruments. A detailed data collection process followed this: (1) Data on respondent characteristics (name, gender, years of service, and employee age) were obtained through a questionnaire and direct interviews with ATCs and pertained to the six study areas; (2) Data on health status were conducted using several health measurements, including the measurement of blood–oxygen levels, pulse, and blood pressure (diastolic and systolic). Blood–oxygen levels and pulse were measured using an oximeter. Blood pressure was measured using a tensimeter. All authors underwent training on using these tools before going into the field. Blood pressure was assessed according to the Joint National Committee on Prevention Detection, Evaluation, and Treatment of High-Pressure VIII, and pulse was assessed as per Price and Wilson (2012). Finally, the blood–oxygen level was assessed based on World Health Organization (WHO) categories (2011); (3) Data on employee productivity. These data were obtained by calculating the amount of traffic controlled by each ATC over one month and attendance and the duration/length of work of that employee over that month. The criteria for work duration were based on Regulation of the General Civil Aviation No. KP 218 of 2017. Total traffic was divided into three categories based on quartile data calculations; (4) Data on feelings of work fatigue. These data were obtained using the Questionnaire for the Measure of Work Fatigue/*Kuesioner Alat Ukur Perasaan Kelelahan Kerja* (KAUPK2), which consists of 17 items on feelings related to fatigue. This instrument was prepared by Lientje Setyawati in 1994, and its validity and reliability have been verified. This parameter measures the feeling of work fatigue as a subjective symptom, in this case among ATCs. Previously, this questionnaire also tested the validity and reliability of ATC employees, who were not respondents. The results obtained were valid and reliable; (5) Data related to work stress. These data were captured via the Occupational Stress and Well-Being among Prison Educators Questionnaire compiled by Gail Kinman and Siobhan Wray in 2013 of the University and College Union, London. This instrument consisted of 47 questions, including the number of sick days, leaves, and a scale of ideal work and personal living conditions. Previously, this questionnaire also tested the validity and reliability of ATC employees, who were not respondents. The results obtained were valid and reliable. Based on quartile data calculations, work stress was divided into three categories: high, moderate, and low stress; and (6) Data related to the quality of life. These data were obtained via the WHO–QOL–BREF questionnaire, compiled in 2004. This instrument consisted of 26 questions across four domains. This instrument was used to determine it each month the quality of life among ATCs, divided into three categories based on quartile data calculations—namely, high, medium, and low.

Having in hand data about individual identity (age, gender, and years of service), health status (pulse, blood–oxygen levels, and blood pressure), productivity, symptoms of work fatigue, and ATC quality of life, a master table in MS Excel was created. The SPSS and AMOS were the software used to analyze these data and determine the effects among the variables, and all were studied using the structural equation modeling (SEM) method.

Results

The results of this study (Table 1) found that among individuals who met the work duration requirements, 82, 51, and 40 ATCs were under high, moderate, and low levels of stress, respectively, all with a significant work duration factor. Additionally, a relationship between work duration (p-value = 0.033) and psychological factors in the form of ATC stress was found; responded to the degree or scale of the separation of work time and personal life indicated a relationship between work time and the opportunity to carry out personal life needs (p-value = 0.007). However, this work-life imbalance triggered stressful conditions that impinged upon the quality of these two factors. This finding aligns with the quality of life assessment of physical, psychological, and social relationships.

Among the participating ATCs, individual identity

Table 1. Test of Significance: Air Traffic Controller Observation Variables

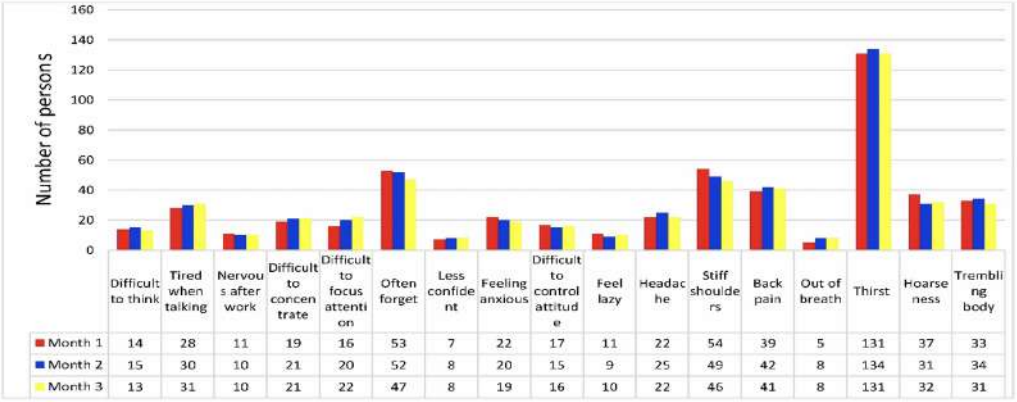
Variable	Category	High Stress	Moderate Stress	Low Stress	p-value
Gender	Female	29 (33.0%)	13 (25.5%)	18 (39.1%)	0.354
	Male	59 (67.0%)	38 (74.5%)	28 (60.9%)	
Age	≥35 years	35 (39.8%)	17 (33.3%)	18 (39.1%)	0.736
	<35 years	53 (60.2%)	34 (66.7%)	28 (60.9%)	
Years of service	≤5 years (new)	31 (35.2%)	19 (37.3%)	14 (30.4%)	0.768
	>5 years (old)	57 (64.8%)	32 (62.7%)	32 (69.6%)	
Pulse (per minute)	High	6 (6.8%)	3 (5.9%)	1 (2.2%)	0.684
	Low	4 (4.5%)	1 (2.0%)	1 (2.2%)	
	Normal	78 (88.6%)	47 (92.2%)	44 (95.7%)	
Blood–oxygen level	Hypoxia	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.575
	Low	1 (1.1%)	0 (0.0%)	0 (0.0%)	
	Normal	87 (98.9%)	51 (100%)	46 (100%)	
Blood pressure	Hypertension	2 (2.3%)	2 (3.9%)	2 (4.3%)	0.567
	Prehypertension	42 (47.7%)	28 (54.9%)	18 (39.1%)	
	Normal	44 (50.0%)	21 (41.2%)	26 (56.5%)	
Productivity	High	37 (42.0%)	22 (43.1%)	16 (34.8%)	
	Moderate	26 (29.5%)	19 (37.3%)	18 (39.1%)	0.639
	Low	25 (28.4%)	10 (19.6%)	12 (26.1%)	
Attendance	Sufficient	19 (21.6%)	8 (15.7%)	5 (10.9%)	0.279
	Good	69 (78.4%)	43 (84.3%)	41 (89.1%)	
Duration of work	Not eligible	6 (6.8%)	0 (0.0%)	6 (13.0%)	0.033
	Qualify	82 (93.2%)	51 (100%)	40 (87.0%)	
The scale of separation: work time and personal life	1	1 (1.1%)	1 (2.0%)	1 (2.2%)	
	2	2 (2.3%)	5 (9.8%)	3 (6.5%)	
	3	6 (6.8%)	2 (3.9%)	3 (6.5%)	
	4	3 (3.4%)	2 (3.9%)	0 (0.0%)	
	5	18 (20.5%)	15 (29.4%)	7 (15.2%)	0.007
	6	18 (20.5%)	3 (5.9%)	2 (4.3%)	
	7	21 (23.9%)	12 (23.5%)	10 (21.7%)	
	8	17 (19.3%)	5 (9.8%)	9 (19.6%)	
	9	88 (2.3%)	6 (11.8%)	11 (23.9%)	
Quality of life: Domain I	Low	22 (25.0%)	24 (47.1%)	39 (84.8%)	
	Medium	25 (28.4%)	19 (37.3%)	4 (8.7%)	
	High	41 (46.6%)	8 (15.7%)	3 (6.5%)	
Domain II	Low	21 (23.9%)	20 (39.2%)	31 (67.4%)	0.001
	Medium	18 (20.5%)	9 (17.6%)	8 (17.4%)	
	High	49 (55.7%)	22 (43.1%)	7 (15.2%)	
Domain III	Low	12 (13.6%)	10 (19.6%)	24 (52.2%)	
	Medium	54 (61.4%)	28 (54.9%)	19 (41.3%)	
	High	22 (25.0%)	13 (25.5%)	3 (6.5%)	
Domain IV	Low	31 (35.2%)	28 (54.9%)	38 (82.6%)	
	Medium	24 (27.3%)	18 (35.3%)	6 (13.0%)	
	High	33 (37.5%)	5 (9.8%)	2 (4.3%)	

(age, gender, and service years), health status (measurement of pulse per minute, blood–oxygen levels, and blood pressure), and productivity were found to have no relationship with the level of stress experienced. Observations vis-à-vis the ATCs' feelings of fatigue (Figure 1) show that over the three consecutive study months, the most common complaint was 'thirsty throat,' from 131, 134, and 131 respondents.

Figure 2 compares the vital signs of ATCs in months 1 and 2. No respondent was found to have experienced hypoxia (e.g., tissue-level oxygen deprivation) during that observation. Of 1.1% of respondents in the AirNav Makassar had experienced a low saturation level, and all others elsewhere had experienced none. In month 2, the saturation level was again found to be low (e.g., 20% of those in the AirNav Bandung had experienced low saturation, and all others elsewhere had experienced none) (Figure 2).

In examining health status (Month 1), it could be seen that 6.7% (2.2%) of the respondents in Makassar had a high (low) pulse rate; in AirNav Bandung, 20% of participants had a low pulse. In Month 2, 6.7% (3.4%) of those at AirNav Makassar had a high (low) pulse rate; at AirNav Denpasar, these numbers were 9.1% and 3%, respectively. At AirNav Surabaya, 7.9% of the respondents had a low pulse rate.

Based on blood pressure measurements (Month 1), it can be determined that 3.4% (44.9%) of the participants at AirNav Makassar had hypertension (prehypertension). At AirNav Lombok, 12.5% (12.5%) of participants had



	Difficult to think	Tired when talking	Nervous after work	Difficult to concentrate	Difficult to focus attention	Often forget	Less confident	Feeling anxious	Difficult to control attitude	Feel lazy	Headache	Stiff shoulders	Back pain	Out of breath	Thirst	Hoarseness	Trembling body
Month 1	14	28	11	19	16	53	7	22	17	11	22	54	39	5	131	37	33
Month 2	15	30	10	21	20	52	8	20	15	9	25	49	42	8	134	31	34
Month 3	13	31	10	21	22	47	8	19	16	10	22	46	41	8	131	32	31

Figure 1. Distribution of Feelings of Fatigue among Air Traffic Controllers in the Six Study Areas

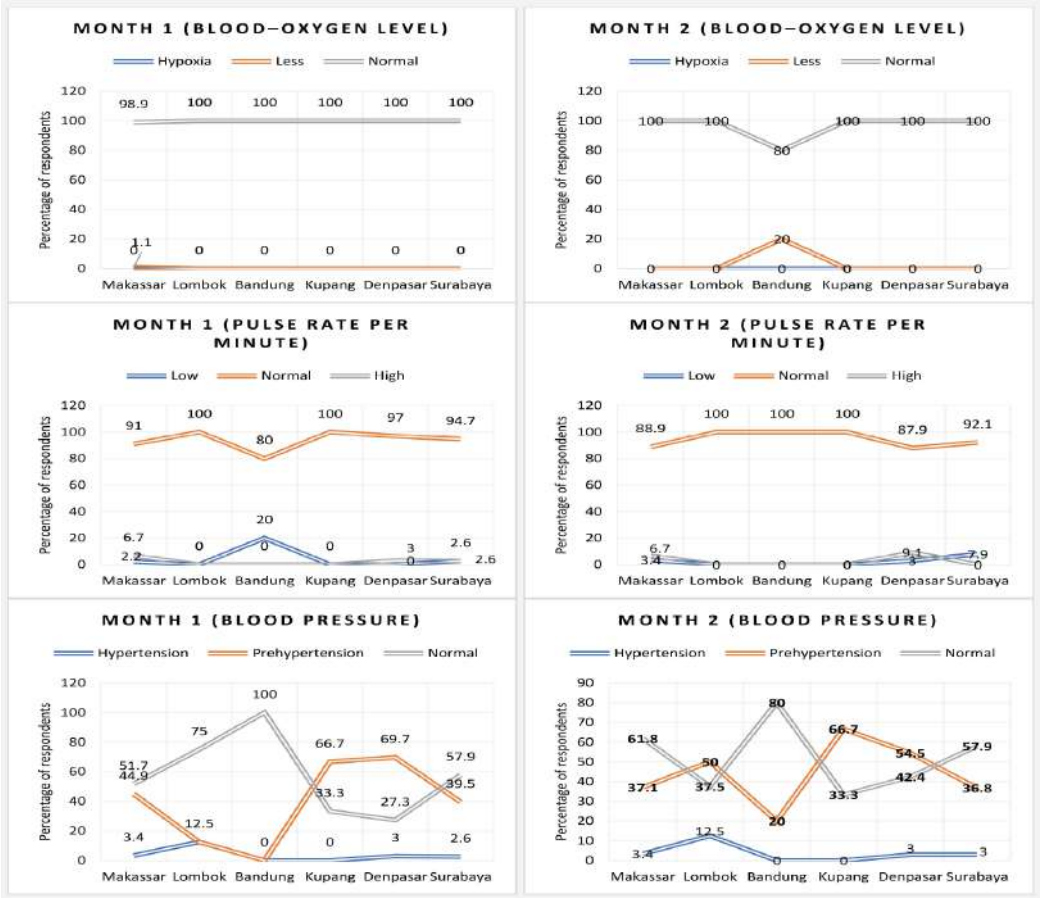


Figure 2. Comparisons of Air Traffic Controllers' Vital Signs (Months 1 and 2)

hypertension (prehypertension), while at AirNav Kupang, 66.7% of participants had prehypertension. At AirNav Denpasar, 69.7% of patients had prehypertension. At AirNav Surabaya, 2.6% (39.5%) had hypertension (prehypertension); in the second month, 3.4% (37.1%) had hypertension (prehypertension). In AirNav Lombok, 12.5% (50%) had hypertension (prehypertension), while in AirNav Bandung (AirNav Kupang), 20% (66.7%) had prehypertension. At AirNav Denpasar, 3% (54.5%) had hypertension (prehypertension), while at AirNav Surabaya, 3% (36.8%) had hypertension (prehypertension).

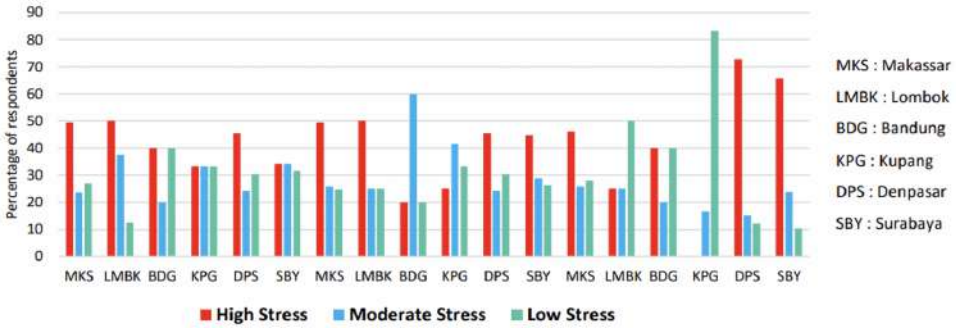
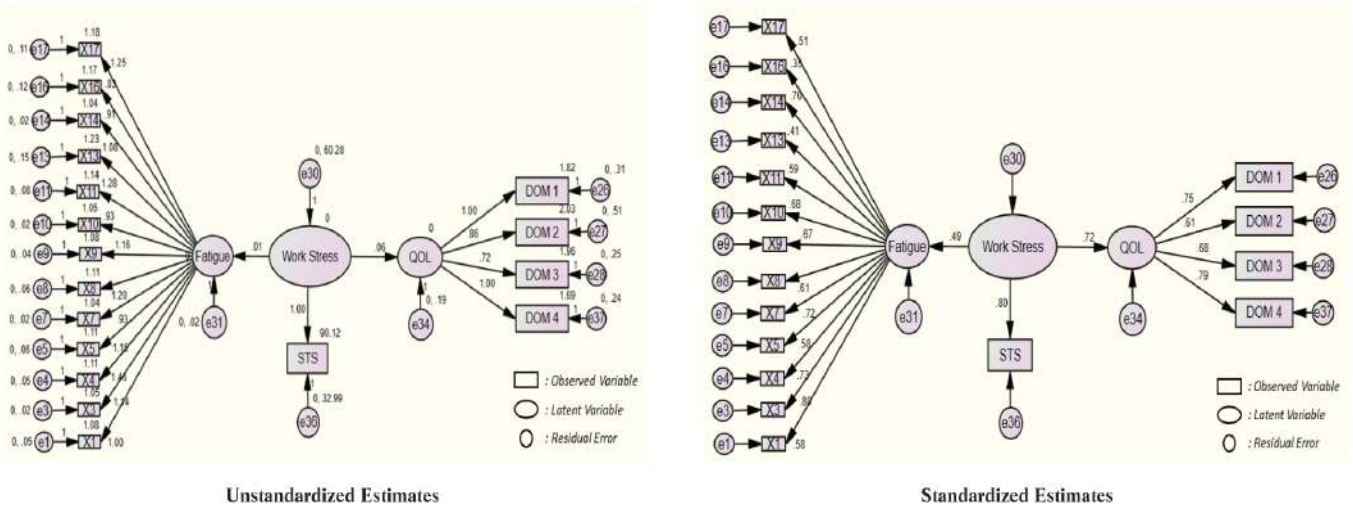


Figure 3. Stress Levels by AirNav Branch in Indonesia (Percent)



Notes: QOL = Quality of Life, STS = Stress, DOM = Domain, X1 = Difficult to think, X3 = Nervous after work, X4 = Difficult to concentrate, X5 = Difficult to focus attention, X7 = Less confident, X8 = Feeling anxious, X9 = Difficult to control attitude, X10 = Feel lazy, X11 = Headache, X13 = Back pain, X14 = Out of breath, X16 = Hoarseness, X17 = Trembling body.

Figure 4. Work Stress Model of Air Traffic Controllers in Indonesia

ATCs at AirNav Surabaya generally experienced stress in Months 1–3, with 34.2%, 44.7%, and 65.8% of participants reporting low, medium, and high-stress levels, respectively. Those at AirNav Denpasar experienced stagnant stress levels in Months 1 and 2 (45.5% each), but in Month 3, that facility recorded the highest high-stress prevalence level (72.7%) (Figure 3).

Based on SEM analysis (Figure 4), the authors found that the stress conditions experienced by the ATCs correlated with fatigue and quality of life: the higher the work stress that causes fatigue, the more it affects ATC quality of life. With each unit of work, stress increases in psychological fatigue (by 0.49) and quality of life (by 0.72).

Based on p-values, the authors found correlations between work stress and quality of life (p-value = 0.001) and feelings of psychological fatigue (p-value = 0.001) to be significant. The psychological fatigue variables were significant for all fatigue indicators (X1–X17 inclusive; p-value = 0.001); similarly, the quality of life variable was significant for all ATC indicators (Domains I–IV inclusive; p-value = 0.001). In addition, the work variables were significant stress indicators (p-value = 0.001) (Table 2, Figure 4).

Discussion

Based on the finding of this study, it was found that while the participating ATCs had good physical health status, they tended to experience poor mental health due to high levels of work pressure. This condition occurs because as air traffic increases, the perceived workload also increases. According to Zhang,[16] the emergence of

Table 2. Results of Structural Equation Modelling Test Analysis

Variable			p-value
Quality of life	<---	Work stress	0.001
Feelings of fatigue	<---	Work stress	0.001
X1	<---	Feelings of fatigue	0.001
X3	<---	Feelings of fatigue	0.001
X4	<---	Feelings of fatigue	0.001
X5	<---	Feelings of fatigue	0.001
X7	<---	Feelings of fatigue	0.001
X8	<---	Feelings of fatigue	0.001
X9	<---	Feelings of fatigue	0.001
X10	<---	Feelings of fatigue	0.001
X11	<---	Feelings of fatigue	0.001
X13	<---	Feelings of fatigue	0.001
X14	<---	Feelings of fatigue	0.001
X16	<---	Feelings of fatigue	0.001
X17	<---	Feelings of fatigue	0.001
Domain I	<---	Quality of life	0.001
Domain II	<---	Quality of life	0.001
Domain III	<---	Quality of life	0.001
Domain IV	<---	Quality of life	0.001
Stress	<---	Work stress	0.001

Notes: X1 = Difficult to think, X3 = Nervous after work, X4 = Difficult to concentrate, X5 = Difficult to focus attention, X7 = Less confident, X8 = Feeling anxious, X9 = Difficult to control attitude, X10 = Feel lazy, X11 = Headache, X13 = Back pain, X14 = Out of breath, X16 = Hoarseness, X17 = Trembling body.

fatigue and stressful conditions interferes with control performance. Fatigue causes ATCs to work more slowly and pay less attention to controlled air traffic situations. This challenge requires ATCs to remain physically and mentally healthy to maintain optimal vigilance. Previous studies also highlight the sources of fatigue among controller officers, both physically and mentally, including the tools used, workloads, work shifts/patterns, traffic, climate, and self-efficacy.[17-25]

The authors found the degree of health to have no correlation with stress. Those findings were insignificance of the hypothesis in research conducted on ATCs related to the standard health inspection system, especially vital signs that are routinely observed. Health controls should be assessed for ATCs at least every six months, and the responsibility of ensuring compliance rests with the employer.[26] The health check system at AirNav is routinely carried out at least every six months so that problems with the health status variable are not a stressor.

The results of the proposed SEM test (Figure 4) show that work stress increases psychological fatigue among ATCs. This result stems from the fact that stress—prompted by various internal and external stressors—is channeled through the nervous system. These stressors activate the glands that produce within the brain the hormones cortisol and adrenaline; these hormones then work together to activate the sympathetic nervous system and ultimately increase the heart rate, control the sweat glands, and make the muscles work more.[27,28] Given the nature of their work demands, ATCs continuously carry out their duties with high intensity, and this triggers factors that result in fatigue. In Indonesia, the ATC profession carries high social and economic status levels in terms of both income and lifestyle. In addition, AirNav Indonesia also monitors ATC health, provides facilities that support ATCs' work, and works to mitigate the risk of occupational illness and accidents.[29] These initiatives increase ATC job satisfaction and, in turn, positively impact their quality of life.

For each problem that ATCs experience, factors need to be resolved in real terms, based on real data; stress-prevalence levels and other results will vary depending on the research methods used. It was found that various psychological factors had adverse effects, though not all stress was unfavorable: there were also positives that ATCs needed to keep moving forward.[30] Some stress requiring intervention was experienced at the individual level,[31] and manifested as depressive conditions. Such issues must be pre-empted through early stress management strategies. The long-term effects of stress contribute to memory loss, gastric ulcers, colitis, musculoskeletal disorders, hypertension, heart disease, cancer development, and death.[32] Work stress was also a potential mediator of low quality of life and negatively impinges upon work performance and productivity.[33-35] Raga,[36] stated that four ATCs at Chicago O'Hare International Airport have died from sudden cardiac events and two from pancreatic cancer. Many others have suffered from stress-related gastrointestinal diseases. These results provided evidence of the extent of mental disorders among ATCs. So it is necessary to provide interventions in the form of routine relaxation, which has an effect similar to that of exercise, in that it stabilizes organ functions.[37]

The provision of relaxation as a control for psychological fatigue among ATCs in Indonesia could reduce the impact of the stress they experience, helping them live healthy, safe, and efficient lives, both at work and home. The findings of this study align with Saleh's,[37] who found a significant difference in work stress between pre- and posttests in the intervention group ($z = -2670$, p-value = 0.008). There was also a significant reduction in work stress following relaxation therapy. Therefore, progressive muscle relaxation techniques are recommended for patients experiencing anxiety, depression, stress, headaches, insomnia, fatigue, muscle spasms, and hypertension.[38]

One advantage inherent in this study design is that the data collection was undertaken three times in three months, thus allowing for comparisons in the respondents' conditions. Another advantage is that this study considers many variables. So the causes of various psychological conditions can be seen from several per-

spectives, including health status, work fatigue, quality of life, and work stress. This study, like any other study, does have weaknesses and limitations. It uses a cross-sectional study design to make no conclusions regarding causality. However, the results of this study can inform future research and act as a reference point in investigating other variables related to psychological fatigue among ATCs.

One possible bias inherent in this study may derive from the lack of guidance given to participants as they executed the questionnaire. The questionnaire was sufficiently long that its execution could have led to boredom and thus hasty or careless answers. This challenge can be overcome by providing questionnaire assistance or conducting interviews with all respondents when collecting data.

Conclusion

In conclusion, stress conditions among air traffic controllers directly affect feelings of fatigue and quality of life. Therefore, organizations and related parties within the aviation sector need to work together to mediate stress experienced by employees and problems deriving from that stress. It is recommended that future researchers measure work stress, feelings of fatigue, and quality of life by adding several variables such as sleep quality, work environment, and work organization, and by using other measuring instruments such as cocorometers and reaction timers.

Abbreviations

ATC: Air Traffic Controller; IATA: International Air Transport Association; IATCA: Indonesia Air Traffic Controller Association; MATSC: Makassar Air Traffic Service Center; KAUPK2: *Kuesioner Alat Ukur Perasaan Kelelahan Kerja*; QOL–WHO: Quality of Life – World Health Organization; SEM: Structural Equation Modeling; WHO: World Health Organization.

Ethics Approval and Consent to Participate

The study was approved by the Research Ethics Committee of Hasanuddin University (Approval ID No. 91018065007).

Competing Interest

The authors declare that there are no significant competing financial, professional, or personal interests that might have affected the performance.

Availability of Data and Materials

The research data are not publicly available, containing the participants' private information.

Authors' Contribution

LMS, SSR, and IT conceptualized and designed the study and interpreted the data. IHY and NMS prepared the study framework and the initial draft. MY and YR analyzed the data and proofread the manuscript.

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Factors Related to Cafe Worker's Lung Capacity in Pontianak, Indonesia

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Abstract

Exposure to cigarette smoke in public places affects the human population lung capacity. Cafe workers are a population susceptible to cigarette smoke exposure. This study aimed to analyze the risk factors associated with the lung capacity of cafe workers. This study used an observational method with a cross-sectional approach. The sample was composed of 74 participants. Data collection was carried out by interviewing and observing respondents. Exposure to inhaled smoke was measured using interviews and a spirometer checking lung capacity. The Chi-square test was used to determine the relationship between risk factors and lung capacity. The results showed a significant relationship between age (p-value = 0.006) and the lung capacity of cafe workers. The older person had, the greater the risk of decreased lung function. There was a significant relationship between cigarette smoke exposure, age, and the lung capacity of cafe workers. The intervention needs to be done to make a preventive measure by establishing non-smoking area regulations in public spaces and monitoring the workplace environment.

Keywords: cafe workers, cigarette smoke, exposure, lung capacity, workplace

Introduction

Occupational health and safety need to be applied in every workplace. It is because occupational health and safety help to achieve optimal work productivity so that every worker can work safely and avoid health problems.[1] For workers to work safely, prevent health problems and achieve productivity at work, promotive, preventive, curative, and rehabilitative efforts are needed.[2] The application of occupational health and safety needs to be done for workers in the formal and informal sectors.[3,4] Occupational diseases and accidents can occur due to poor working conditions, such as air pollution by solid particles in the form of dust and smoke, which can reduce the quality of life for workers in the workplace.[5-7] Among diseases that can cause death, 34% originate from cancer, 24% occupational accidents, 21% respiratory diseases, 15% cardiovascular disease, and 5% are caused by other factors.[8]

One of the causes of respiratory disease in the workplace is exposure to cigarette smoke. It is one of the causes of respiratory disease in the workplace. Cigarettes are a combination of complex chemicals: carbon monoxide, hydrogen cyanide, nitrogen oxides, benzene, formaldehyde, acrolein, phenol, nicotine, nitrosamines, and other gases. Many chemicals in it can cause health problems, one of which is respiratory disease.[9] Passive smoke can affect the respiratory tract, and both who smoke actively or passively can develop health problems.[10]

Exposure to cigarette smoke causes increased airway inflammation and the onset of respiratory symptoms, such as asthma, bronchitis, and chronic obstructive pulmonary disease.[11] Exposure to secondhand smoke is one of the air pollutants. As many as 35% of women, 33% of men, and 40% of children from 192 countries worldwide are exposed to passive smoke indoors.[12] According to the Global Adults Tobacco Survey, restaurants and cafes are public places that are most susceptible to its spread (85.4%).[12] Cafe workers are a group of passive smokers and vulnerable to it. The World Health Organization (WHO),[13] stated that there is no safe limit for exposure to other's smoke; separating smoking and ventilation spaces will not reduce smoke inhalation. A total of 70 cafes and restaurants employees

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experienced moderate restrictions.[14] Cigarette smoke exposure is a risk factor for decreased lung function status, causing health risks.[15]

The effect of smoke exposure affects the functional lung capacity of workers. Finding cafes or restaurants indoors and outdoors in Pontianak City is not difficult; they are spread along the roads.[16] The number of cafes and restaurants is also in line with the smoking culture. Pontianak City has a Regional Regulation/*Peraturan Daerah* (PERDA) No. 10 of 2010 concerning non-smoking areas. However, implementing of a smoke-free zone in cafes and restaurants is complicated to implement. Many cafes and restaurants still give visitors the freedom to smoke indoors or outdoors or even provide smoking rooms. This study aimed to analyze the relationship of exposure to cigarette smoke, age, gender, working period, working length, and air conditioning with the lung capacity of cafe workers. This study was conducted in Pontianak City because it is one of the cities that has a strong hangout culture.[16]

Method

The study design used was cross-sectional. The total population used was all workers at 24 cafes with permits from One-Stop Integrated Agency and Investment Office of Pontianak City. However, 15 cafes were willing to participate, two refused, and seven were no longer operating. There was a total population of 15 licensed cafes with 92 workers. According to Sugiyono,[17] if the total population was less than 100 workers, all can be used as a study sample. The sample in this study is the total population with inclusion and exclusion criteria, and 74 workers met the requirements. The study was carried out from January 2019 to June 2019. The inclusion criteria of the study sample were no history of lung-related diseases, such as pneumonia, tuberculosis, bronchitis, and asthma,[18] and normal nutritional status (a balance between the amount of energy that entered the body and energy released from outside the body according to individual needs). The body mass index (BMI) was used by calculating weight divided by height squared. The threshold value of BMI with a normal category is 18.5-25.0 kg/m^2.[19] The exclusion criterion was if the workers were unwilling to participate in the study activities.

This study's data collection techniques were carried out by interview, observation, and examination. Respondent characteristic data, such as age, gender, working period, and working length, were obtained using interviews using questionnaires. The data was collected before work and rest. Data on cigarette smoke exposure and air conditioning system (air conditioner/AC and fans) were obtained using interviews and observations by questionnaires and checklists. The data was collected when the workers worked. The lung capacity categorized as normal if forced vital capacity (FVC) $\geq$ 80% and forced expiratory volume in one second (FEV1) $\geq$ 75% and disruption if FVC < 80% and FEV1 < 75%. The data was measured by examination using a spirometer and checked according to the American Thoracic Society Standardization of Spirometry guidelines.[20] The data was collected after the respondent finished working. Data collection officers were enumerators who had been trained while lung capacity checks were carried out.

The management of data was using a statistical analysis program included the stages of editing, coding, scoring, entry, tabulating, and analyzing the study data processing method included the following: 1) editing (data checking), which was cleaning and preparing the data that had been collected, answers were complete, clarity and suitability; 2) coding (code giving) was the identification and classification process by giving symbols in the form of numbers on each respondent's answer based on the variables studied; 3) scoring (scores) consisted of giving a score to the data that had been coded, and then assigning a value and weight to the data; and 4) tabulating (entering data in a table), which was doing data entry, compiling and calculating the data that had been coded into a table. Furthermore, the data processing results were analyzed descriptively and underwent inferential analysis. Descriptive analysis data was presented in tables, presentations, frequency, and narration. Bivariate analysis with statistical tests using the Chi-square test was used to analyze whether or not there was a relationship between the independent and dependent variables. Multivariate analysis using logistic regression test or binary logistic regression with a 95% confidence level (α = 5%) was performed.

Results

The variable-frequency distribution among cafe workers in Pontianak City was seven variables divided into several categories, as shown in Table 1. Table 1 shows that 22 (29.7%) cafe workers were exposed to cigarette smoke. There were 52 cafe workers aged $\geq$ 20 years (70.3%) and dominated by female workers (40; 54.1%). Sixty-nine workers had an average working period of less than five years (93.2%), and 39 workers had a $\geq$ 7 hours/day length of work (52.7%). The types of air conditioning system used in the observation area were fans and air conditioners (64.9%). The lung capacity of 52 cafe workers showed normal categories (70.3%).

Based on Table 2, the number of respondents exposed to cigarette smoke is the same; 50% experiencing interference and 50% normal. The statistical results showed the p-value of 0.028 (odds ratio (OR) = 3.7; 95% confidence interval (CI) = 1.281-10.848), indicating a

relationship between cigarette exposure and lung capacity in cafe workers. Workers who experienced lung capacity disorders (54.2%) were less than 20 years old. The statistical results showed the p-value of 0.006 (OR = 5; 95% CI = 1.701-14.934), indicating a relationship between age and lung capacity in cafe workers. Many workers who experienced lung capacity disorders were male (32.4%). The statistical results showed the p-value of 0.841 (95% CI = 0.464-3.424), indicating no relationship between gender and lung capacity in cafe workers. Approximately 40% of workers who had a work period of ≥ 5 years experienced lung capacity disorders. Statistical results showed a p-value of 0.630 (95% CI = 0.253-10.526), indicating no relationship between years of service and lung capacity in cafe workers. Workers who had a work period of ≥ 7 hours/day experienced lung capacity disorders (30.8%). The result of statistical analysis was a p-value of 1.000 (95% CI = 0.409-3.021), which means that there is no relationship between the length of work and the lung capacity of cafe workers. Workers who used AC experienced lung capacity disorders (38.5%). The

Table 1. Distribution of Cafe Workers in Pontianak City

Variable	Category	n	%
Exposure to cigarette smoke*	Inhalation	22	29.7
	Not inhaled	52	70.3
Age	<20 years	22	29.5
	≥20 years	52	70.3
Gender	Male	34	45.9
	Women	40	54.1
Working period	≥5 years	5	6.8
	<5 years	69	93.2
Working length	≥7 hours/day	39	52.7
	<7 hours/day	35	47.3
Air conditioning system	Fan	13	17.6
	Air conditioner (AC)	13	17.6
	Fan and AC	48	64.9
Lung capacity	With disruption	22	29.7
	Normal	52	70.3

Notes: Sources: Primary Data, 2019
*Respondents as passive smoker

Table 2. Bivariate Analysis of Factors Related to the Lung Capacity of Cafe Workers

Variable	Category	Lung Capacity						p-value[a]	OR	95% CI
		With Distraction		Normal		Total				
		n	%	n	%	n	%			
Cigarette smoke exposure	Inhalation	11	50	11	50	22	22	0.028*	3.7	1.281-10.848
	Not inhaled	11	21.2	41	78.8	52	52			
Age	<20 years	12	54.2	10	45.5	22	100	0.006*	5	1.701-14.934
	≥20 years	10	19.2	42	80.8	52	100			
Gender	Male	11	32.4	23	67.6	34	100	0.841*	-	0.464-3.424
	Female	11	27.5	29	72.5	40	100			
Working period	≥5 years	2	40	3	60	5	100	0.630*	-	0.253-10.526
	<5 years	20	29	49	71	69	100			
Working length	≥7 hour/day	12	30.8	27	69.2	39	100	1.000*	-	0.409-3.021
	<7 hour/day	10	28.6	25	71.4	35	100			
Air conditioning system	Fan	1	7.7	12	92.3	13	100	0.150*	-	-
	Air conditioner (AC)	5	38.5	8	61.5	13	100			
	Fan and AC	16	33.3	32	66.7	48	100			

Notes: Source: Primary Data, 2019
[a]Chi-square, α = 5%, *Significance p-value≤0.05, OR = Odds Ratio, CI = Confidence Interval

Table 3. Multivariate Analysis of Factors Related to the Lung Capacity of Cafe Workers

Variable	β	SE	Wald	df	Sig[a]	Exp(B)	95% CI for Exp(B)	
							Lower	Upper
Age	-2.144	0.654	10.762	1	0.001	0.117	0.033	0.422
Gender	-1.029	0.623	2.727	1	0.099	0.357	0.105	1.212
Cigarette smoke exposure	0.566	0.631	0.806	1	0.369	1.761	0.512	6.061
Working period	0.292	1.109	0.069	1	0.792	1.339	0.152	11.763
Working length	0.152	0.607	0.063	1	0.802	1.164	0.355	3.822
Air conditioning system	1.798	1.210	2.207	1	0.137	6.038	0.563	64.733
Constant	-0.259	3.299	0.006	1	0.938	0.772		

Notes: Source: Primary Data, 2019
[a]Logistic regression test or binary logistic regression test, α = 5%, *Significance p-value≤0.05
SE = Standard Error, df = degrees of freedom, Exp(B) = Exponent B (Odds Ratio), CI = Confidence Interval

statistical value of p-value = 0.150 shows no relationship between air conditioning system and lung capacity in cafe workers. Based on Table 3, the results of the age analysis had a significant value compared to other variables (p-value = 0.001; 95% CI = 0.033-0.422).

Discussion

Based on the bivariate statistical analysis, there was a relationship between exposure to cigarette smoke and lung capacity in cafe workers in Pontianak City (p-value = 0.028; OR = 3.7; 95% CI = 1.281-10.848). Smoking can cause health problems, especially respiratory problems, including lung function capacity, which can cause high morbidity from respiratory disorders or risk of death.[21] Smoking habits can affect lung function by decreasing it. There are addictive substances in cigarettes that can damage human respiratory organs, especially the lungs, which can cause damage to function and tissue structure in the lungs.[15] Secondhand smoke is smoke from active smokers inhaled unconsciously by passive smokers.[22]

Cigarette smoke contains more than 7,000 chemicals in it. Hundreds of them are toxic chemicals, and about 70 of them can cause cancer. No level of passive smoke is risk-free. Even brief exposure can cause immediate harm.[22] Cigarette smoke can disrupt the diffusion process of decreased O_2 supplies in tissues. It can lead to hypoxia, disruption of metabolic processes, and an increase in CO_2 in the blood, causing a decrease in the vital capacity of the lungs.[23] Based on the study of Bird and Staines-Orozco,[24] it was stated that passive smoking causes an increase in respiratory symptoms and a decrease in a person's functional lung capacity. Smoking causes changes in the function of the human respiratory tract. It disrupts lung function caused by hypertrophic mucosal cells and hyperplastic mucus glands, resulting in mucus buildup that causes inflammatory cells to increase in the lungs and alveoli, inducing damage.[25] The habit of smoking causes the emergence of more and more lung deposits so that the air in and out becomes increasingly narrow.[26]

The statistical results show a p-value of 0.006 (OR = 5; 95% CI = 1.701-14.934), indicating a relationship between age and lung capacity in cafe workers. Based on the results of multivariate analysis, age has a significant (p-value = 0.001) value compared to other variables. Its factors were one of the factors that affected the condition of a person's lungs. As age increases, the function of organs and the human immune system also decreases, especially changes in the lungs, such as changes in the nervous system, tissues, and muscles. Age was one of the crucial factors that could affect the condition of a person's lungs. In older people, the function and performance of the body decreases with age, which results in several changes in the lung organs, such as changes in muscle, bone, and nervous system tissue, as well as changes in the immune system.[27]

Each person's lung capacity will decrease by 20 mL each year. When a person reaches the age of 30, their lung function value will decrease by 3,000 mL to 3,500 ml, while in a person over the age of 50, their lung function value decreases to less than 3,000 mL. Based on the statistical results, the p-value of 0.841 indicates no significant relationship between gender and lung capacity in cafe workers.[28,29] These results were in line with the study of Kandung,[30] who found that gender does not show an effect on lung function disorders because both males and females have the same risk of experiencing pulmonary function disorders. Reduced lung function is caused by a decrease in the elasticity of the tissue in the lungs. As a person ages, the respiratory muscles in the lungs, FEV1 and FVC, vital capacity, and antioxidant fluid of the epithelium decrease.[31]

The lung function volume and capacity in women are 20-25% smaller than in men, and the average lung capacity for adult women and men is different. So, there is no relationship between gender and lung capacity in cafe workers. The results showed that 32.4% of male workers had lung capacity disorders because some of them were active smokers. Active smoking can increase respiratory disorders, such as impaired lung capacity, chronic obstructive pulmonary disease, lung cancer, emphysema, and bronchitis.[32] Working period was found to have no significant relationship with lung function disorders in workers with a p-value = 0.630. This is in line with Yuvaraj, *et al.*,'s study stating that working tenure is not related to pulmonary function disorders in workers because the respondents who work at cafes had a working period of fewer than ten years.[33]

The use of air conditioning systems and lung capacity in cafe workers did not show a significant relationship, with a p-value of 0.150. The air conditioning system used in the cafe where the observation was located used two types; an AC and a fan. The results showed that AC increased impaired lung function capacity by 38.5%. The use of an air conditioning system cannot control the exposure to passive smoke because this system can spread exposure to cigarette smoke throughout the room and cause health problems. Therefore, improving indoor and outdoor air quality is an effort to protect the health and safety of employees and customers.[34] Air circulation is crucial to prevent contamination in the room.[12]

An increased ventilation rate plays an essential role in air distribution to remove disease-causing pollutants.[35] The call for a smoking ban effectively improves both indoor and outdoor air quality. This has been shown to be effective in eliminating the risk of health problems associated with exposure to cigarette smoke indoors.[34]

Providing a smoking area can minimize exposure to cigarette smoke, provided that pollutants originating from cigarette smoke from the smoking area flow out without recirculating to another occupied room.[36] To protect workers from exposure to cigarette smoke, the WHO,[37] recommends a policy regarding the implementation of a smoke-free environment in public spaces; this is considered the most effective way to reduce cigarette smoke exposure to a safer level both outdoors and indoors. Ventilation and designated smoking areas either have separate ventilation from smoke-free areas or do not reduce exposure to a safe level of risk and are not recommended.

The limitation of this study was that it used a cross-sectional approach, so the study may change in the future due to the limited time of the study and only proving the relationship between the variables that occurred during the study. Also, the upcoming changes could not be observed. The sample size was not large, so the study results could not be generalized to a population; the various factors associated with pulmonary disorders cannot be controlled. This study only looked at the relationship between one or several variables with other variables but could not conclude whether there was a causal relationship. The recommendation for future study is to be carried out experimentally by comparing the control and exposed groups. Respondents who meet the inclusion criteria must undergo a medical examination according to the procedure (not only by filling out a form).

Conclusion

There is a relationship between exposure to cigarette smoke and lung capacity in cafe workers and age. Based on the multivariate analysis, there was a relationship between age and lung capacity in cafe workers. Based on this study results, the authors suggest cafe visitors be more positive in obeying the rules of the no-smoking area and for the Department of Health, Department of Trade, and Department and Industry to take preventive measures by making smoking protocols or rules in public rooms monitoring the workplace environment.

Abbreviations

WHO: World Health Organization; PERDA: *Peraturan Daerah*; BMI: Body Mass Index; OR: Odds Ratio, CI: Confidence Interval; O_2: Oxygen, CO_2: Carbon dioxide, AC: Air Conditioner; FEV1: Forced Expiratory Volume in one second; FVC: Forced Vital Capacity.

Ethics Approval and Consent to Participate

This research was conducted in accordance with the Declaration of Helsinki guidelines and approved by the Poltekkes Kemenkes Pontianak (No.195/KEPK-PK.PKP.V/2019). Written consent was obtained from all workers who participated in the study.

Competing Interest

The author declares 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 supporting the findings of this study are available upon request from the author. Data are not publicly available due to the ethical constraints of the research.

Authors' Contribution

S takes responsibility for the integrity and accuracy of the data and the drafting of the manuscript and also wrote the primary draft of the manuscript. ZA and FRP are responsible for the design of the study and contributed to the analysis and interpretation of the data.

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Impact of Occupational Fatigue on Human Performance among Oil and Gas Workers in Indonesia

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Abstract

Occupational fatigue is a serious problem since it may cause several issues, including deteriorating human performance. Some major accidents in the oil and gas industries were associated with the lack of human performance due to occupational fatigue. This study aimed to analyze the impact of occupational fatigue on human performance among oil and gas workers in Indonesia. This study used a cross-sectional design using a self-administered validated questionnaire to gather information on demographic (gender and age), work characteristics (work rotation, work duration, shift work model, day/night shift, job position), sleep debt, sleep quality, occupational (acute and chronic) fatigue, and at-risk behavior as the indicator of human performance. In this study, a total of 1,650 workers from different fields (production, drilling, well service, construction, and administration/office) participated. This study showed that occupational fatigue (both chronic and acute) has potentially decreased level of human performance. This implied that managing occupational fatigue may prevent deteriorating human performance.

Keywords: at-risk behavior, business continuity, fatigue, human performance, oil and gas workers

Introduction

Fatigue is one of the contributors to human errors and results in slower reactions. It reduces the ability to process information, memory lapses, absent-mindedness, decreased awareness, lack of attention, underestimation of risk, and reduced coordination.[1,2] Fatigue can lead to errors and accidents, moreover in workplaces. The Health and Safety Executive of the United Kingdom even stated that fatigue contributes to 20% of accidents on major roads and causes financial costs.[2] Oil and gas industries are well known to be linked to very-high-risk operations. A small mistake (at-risk performance) may lead to a catastrophic incident resulting in multiple fatalities, environmental damage, loss of assets, and business disruption.

The British Petroleum Texas City Refinery accident on March 23, 2005, caused fifteen fatalities, 180 injuries, and financial losses of up to more than US$ 1,5.[3] From the results of The U.S. Chemical Safety and Hazard Investigation Board (CSB) investigation, it was also found that the workers experienced sleep deprivation, some of them forced to work overtime due to a reduction in workers.[4] The British Petroleum had to pay a total compensation cost of US$65B after the incident.[5] The investigation revealed that some crewmen were working three weeks offshore and were thus perhaps suffering from fatigue. There was a similar incident at the Deepwater Horizon oil rig in the Gulf of Mexico on April 20, 2010. The drilling rig was preparing to temporarily abandon the Macondo Well when it, unfortunately, experienced a kick and ended with a disastrous oil spill in the Gulf of Mexico. The oil rig's crew was also exposed to commercial pressure to speed up the temporary abandonment procedure, which was already six weeks behind schedule.[6]

The British Petroleum Texas City and Deepwater Horizon incidents show that defective human performance can lead to major incidents or business disruption. In many industrial incidents, fatigue was observed to be the critical factor that influenced human performance.[7] It was also explained that when workers experience excessive fatigue, they will be unable to make the right decisions or find it difficult to do so. Especially when there is an emergency situation or when excessively fatigued workers come to face a life-threatening condition, the probability of them making a wrong decision increases

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up to 99%.[8] Mostly, a wrong decision caused by fatigue can lead to impaired reasoning, decreased decision-making ability, reduced vigilance and focus/attention, reduced mental functioning. This decision is usually low reaction time, temporary loss of situational awareness, bypassing procedures, or shortcuts.[9]

Occupational-fatigue risk factors as consisting of three main groups: individual factors, work factors, and non-work-related factors.[10] The individual factors include age, health status, and adaptability. Work factors include roster pattern, work time, poor work scheduling, shift time, type of work done, continuous demanding work, and position level/decision latitude. Non-work-related factors include recovery time between shifts, long periods of awake time, inadequate rest breaks, a non-conducive environment, lack of sleep and rest, poor quality of sleep, other employment, and excessive travel time.[10]

Acute fatigue is fatigue after a period of physical and mental stress, including strenuous muscle effort, immobility, heavy mental workload, intense emotional distress, monotony, and lack of sleep.[11] If acute fatigue is experienced continuously over a long period and there is no adequate recovery, it will develop into chronic fatigue. Chronic fatigue brings with it a combination of physiological and psychological problems.[11] Fatigue that workers experience has the potential to cause negligence and poor judgment.[9]

When workers experience or are exposed to fatigue, their performance will decrease. This decrease has the potential to cause human error. Gerald Matthews, *et al.*,[12] showed that each individual has different susceptibility (Individual Differences IDs) to the fatigue they experience. The human performance decrease is mainly determined by the level of vulnerability (fatigue vulnerability) and resilience (fatigue resistance) of each worker IDs.[12]

Therefore, managers need to know the relationship between worker fatigue and human performance, so they will be able to anticipate potential incidents by managing the factors contributing to worker fatigue in the organization by developing a fatigue risk management system (FRMS).[13] This study aimed to analyze the association between work fatigue and human performance among Indonesian oil and gas workers. The results of this study can be considered to prevent and control worker fatigue in the workplace and maintain and improve human performance for business continuity management.

Method

This cross-sectional study used a self-administered validated questionnaire to measure occupational fatigue using a standard method, "Occupational Fatigue Exhaustion Recovery (OFER)," as the independent variable and nine at-risk behaviors to predict the change of human performance as the dependent variable. In order to have represented the sample, this study used random sampling method. The sample calculation refers to Roscoe (1975) quoted by Sakaran U,[14] the minimum sample required is 10 times the number of variables. In this study the number of variables was 25 variables. Thus, the minimum sample required was 10 x 25 = 250 sample. The sample inclusion criteria in this study were all employees of oil and gas at Perusahaan Migas X. Meanwhile, the exclusion criteria in this study were employees who were sick, on leave, and workers who were not willing to fill out questionnaires. This study was deployed to all entities in the organization, such as the Production & Maintenance Department, onshore & offshore fields workers, drilling rigs & well servicing, construction, and administration/office. There were 1,573 data out of 1,650 total respondents included in this study analysis, and 77 were excluded (50 data were used for questionnaire validity test, and the other 27 data were incomplete and thus considered invalid).

The OFER standard questionnaire developed by Windwood, *et al.*,[15] consisted of 15 questions, including three sub-scales; acute fatigue five questions, chronic fatigue five questions, and inter-shift recovery five questions. All subscales were scored using 7-point Likert Scale and scored 0-100.[15] Overall, the results of the acute and chronic fatigue calculation were grouped into four quartiles of 0-100 (e.g., scores 0–25 was categorized as a mild acute or chronic fatigue level; 26-50, moderate acute or chronic fatigue level; 51-75, high acute or chronic fatigue level; and 76-100, very high acute or chronic fatigue level).

At-risk performance was measured using a self-administered questionnaire which adopted from the U.S. Department of Energy (DOE),[9] and had been tested for the reliability and validity. The results of the validity test showed all the questions in the questionnaire were valid that showed by the significant value (2-tailed) was 0.000 (p value<0.05). The reliability test, used the Cronbach Alpha test, showed an alpha value of 0.883 where the value into the category of high reliability. The at-risk performance questionnaire consist nine at-risk behaviors when the respondents worked in a fatigued state in the last 12 months before the survey (Table 1). These nine at-risk behaviors are shown below.

At-risk 1 – Working while tired/sleepy
At-risk 2 – Short memory loss
At-risk 3 – Mis-prediction/anticipation
At-risk 4 – Wrong/poor decision
At-risk 5 – Slow body movement/reflex
At-risk 6 – Taking a shortcut/skipping or bypassing a task in the task sequence
At-risk 7 – Lack of focus/attention

At-risk 8 – Working in a hurry
At-risk 9 – Lack of verification (over-assumption)

The total at-risk behavior score is cumulative of nine individual answers: never = 0, once = 1, and more than one = 2. The total score for each respondent will vary from 0 to 18. The gathered data were analyzed using Stata for Windows version 12.1 for the univariate and multivariate analysis.[15] Level of acute and chronic fatigue, a score of acute and chronic fatigue, and human performance respondents were variables explained by univariate analysis. Single linear regression linear analysis was used to determine the relationship between acute fatigue score and chronic fatigue score as independent variables and human performance score as the dependent variable. The significance of multivariate analysis was alpha 5%. If p-value<0.05, it means that acute fatigue and chronic fatigue significantly could predict human performance.

At-Risk Behavior (When Working in a Fatigued State in the Last 12 Months before This Survey)	Never	Once	More than Once
Have you ever experienced working with a limp, powerless, or in a tired body condition?	O	O	O
Have you ever experienced short-term memory loss (forgetting or not realizing what you just did)?	O	O	O
Have you ever mispredicted something?	O	O	O
Have you ever been unable to make the right decision at work or had difficulty making one?	O	O	O
Have you ever felt slow in responding to unsafe conditions?	O	O	O
Have you ever bypassed tasks/job sequences or decided to perform only those steps you considered important (skipping seemingly unimportant steps or deviating from the proper sequence/order of tasks)?	O	O	O
Have you ever experienced being misfocused, wanting to do A but ending up doing B instead (e.g., wanting to turn left but instead turning right)?	O	O	O
Have you ever left a task unfinished or left the workplace early?	O	O	O
Have you ever done something relying only on your assumption/prediction (e.g., coming up with a report without checking from the field)?	O	O	O

Table 1. At-Risk Behavior Questionnaire

Table 2. Distribution of Respondents with Acute and Chronic Fatigue Levels

Level of Fatigue	Chronic Fatigue		Acute Fatigue	
	n	%	n	%
Mild	734	46.66	316	20.09
Moderate	521	33.12	825	52.45
High	252	16.02	350	22.25
Very high	66	4.20	82	5.21
Total	1,573	100.00	1,573	100.00

Results

The distribution of respondents age between 20 – 57 years old which age mean in 37 years old. Mostly respondents work in onshore field (46.4%) and the second one was swampy field (43.2%). Mostly respondents (75.5%) have 12 working hours. A total of 53.6% of respondents worked with a shift work system. Respondent positions vary, consisting of manager, superintendent/assistant manager, foremen/supervisor, operator/technical/crew of land/sea/air transportation, and assistant operator/helper. The most position of the respondents was operator/technical/crew of land/sea/air transportation (52.4%).

Table 2 shows the distribution of the respondents with acute and chronic fatigue levels based on their score assessments. On average, almost all workers were at a moderate level of fatigue (score 26-50). Table 3 shows that the average acute fatigue score of the respondents was 42.3 (95% confidence interval (CI) = 41.3–43.2), with a standard deviation of 19. Meanwhile, the average chronic fatigue score of the respondents was 31.9 (95% CI = 30.8–33), with a standard deviation of 22.62.

The study participants' human performance was assessed using nine questions regarding the at-risk behaviors experienced by the worker respondents in the last

Table 3. Distribution of Acute and Chronic Fatigue Scores

Variable	Mean	SD	Minimum-Maximum	95% CI
Acute fatigue	42.3	19	0–100	41.3–43.2
Chronic fatigue	31.9	22.62	0–100	30.8–33.0

Notes: CI = Confidence Interval, SD = Standard Deviation

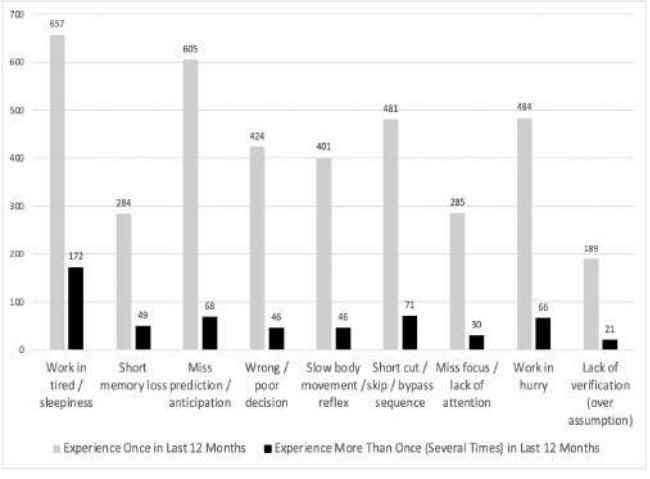

Figure 1. At-Risk Behaviors of the 1,573 Respondents

Table 4. Association between Acute Fatigue and Human Performance

Independent Variable	R^2	p-value	B (CI)	95% CI (B)
Constant			104.353	102.361–106.345
Acute fatigue	0.261	<0.001	-0.511	(-0.560)–(-0.474)

Notes: CI = Confidence Interval, Dependent variable = Overall performance

Table 5. Association between Chronic Fatigue and Human Performance

Independent Variable	R^2	p-value	B (CI)	95% CI (B)
Constant			98.183	96.840–99.525
Chronic fatigue	0.261	<0.001	-0.491	(-0.525)–(-0.457)

Notes: CI = Confidence Interval, Dependent variable = Overall performance

12 months before the survey. Of nine at-risk behaviours reported during the last 12 months, work in tired/sleepiness, miss prediction/anticipation, work in hurry, and short cut/skip/bypass were the most at-risk behaviours reported. In addition, all at-risk behaviours were experiences more than once (several times) a year (Figure 1).

Tables 4 and 5 show the results of the single linear regression analysis of how the worker respondents' human performance was affected by their acute and chronic fatigue as independent variables. The associated correlation based on Table 4 can be interpreted using the formula: HP = 104.353 – 0.511 AF, where HP is Human Performance and AF is Acute Fatigue. The associated correlation based on Table 5 can be interpreted using the formula: HP = 98.183 – 0.491 CF, where HP is Human Performance and CF is Chronic Fatigue.

Discussion

The results of the study showed that most of the workers experience moderate acute fatigue. However, there were several workers experiencing high acute fatigue and even very high acute fatigue. This result must be a concern because a barrier failure can cause an accident due to high or very high fatigue. When workers experience acute fatigue continuously over a long time with no adequate recovery, it will accumulate, resulting in chronic fatigue.[11,16] In this study, most of the workers in Perusahaan Migas X experienced mild chronic fatigue. Mild chronic fatigue can develop into moderate, high, and very high chronic fatigue levels. Chronic fatigue can cause health problems for workers, especially in the nervous system and immune system.[17] In addition, it is paramount to note that there are workers who experience high levels of chronic fatigue and even very high levels of chronic fatigue. Chronic fatigue at high and very high levels has the potential to cause an accident in the workplace.

The findings of this study also showed that acute and chronic fatigue significantly impacted the human performance of workers. Acute and chronic fatigue negatively correlated to human performance, which means the more workers experience acute and chronic fatigue, the greater the decrease in their work performance. The human performance score decreased by 0.511 to increase acute fatigue value (Table 4). In other words, for every increase in chronic fatigue, human performance will decrease by 0.491 (Table 5). This result was in line with the finding of the study by the US DOE that a higher level of fatigue is likely to degrade work performance (increase in the probability of human errors, lapses, slips, mistakes, errors, and violations; negligence (human error); and inadequate judgment).[9] In addition, other previous studies showed that fatigue was one of the contributors to bad human performance, known as a human error which consists of lapses, slips, mistakes, and violations in the petrochemical, oil, and gas industry.[18] Furthermore, Yeow, *et al.*,[19] found that 48.8% of human errors committed by the subjects in her study were caused by fatigue, stress, work repetition, and the work environment.

In this study, human performance was indicated by nine at-risk behaviors. They were working while tired/sleepy, temporary memory loss, misprediction/anticipation, wrong/poor decision. They also work slow body movement/slow reaction time, take a shortcut/skipping or bypassing a task in the task sequence, lack of focus/attention, work in a hurry, and lack of verification (over assumption). This study also showed a similar result with Enoka and Duchateau,[20] that fatigue led the workers to experience impaired reasoning and decision making and decreased alertness/attention. Fatigue also slows down mental function and reaction time and leads to loss of situational awareness (forgetting for a moment) and shortcuts. Fatigue is considered an unsafe condition in the workplace as it is likely to increase the risk of accidents.[1,19]

The most at-risk behavior experienced by workers in Perusahaan Migas X is working while tired/sleepy, either experienced once or several times in the last twelve months. While working in tiring conditions, workers have the potential for negligence, poor judgment, and decreased preparedness that potentially caused accidents.[9,21] Poor judgment happens as a consequence of a decrease in mental function. Furthermore, taking a shortcut/skipping or bypassing task sequence was the second most at-risk behavior in this survey. They were taking a shortcut/skipping or bypassing a task in the task sequence. A procedural violation is a deviation from the correct working method and introduces risk to practice.[21] The background of shortcuts is a motivational problem of the workers. Workers take shortcuts when

they consider some procedure steps trivial and do not fit their individual.[22] Shortcuts increase the potential of an accident in the workplace because there were maybe the critical steps in the task sequence that workers bypassed.

In general, this study explained that most respondents reported having at-risk behaviors in various forms, implying negative human performance. Occupational fatigue may play a role, as shown that increasing occupational acute or chronic fatigue scores significantly increased at-risk behavior scores, which means more negative human performance. Occupational fatigue significantly impacted human performance by observing at-risk behavior among oil and gas workers. However, considering this study was conducted in the COVID-19 pandemic condition where several risk factors of fatigue could be different from normal. The authors suggest that the following study should be conducted in a normal situation.

Conclusion

During the last 12 months, the most-reported at-risk behaviors were working in tired/sleepiness, mis-prediction/anticipation, work in a hurry, and shortcut/skip/bypass. In addition, this study also found that occupational fatigue could cause a negatively impacts on human performance as it increases at-risk behavior among workers could lead to an incident, considering fatigue was one of many factors that could impacting to human performance. Therefore, understanding this condition is paramount to all managers to manage fatigue risk in the workplace in the Fatigue Risk Management System (FRMS) frame.

Abbreviations

CSB: Chemical Safety and Hazard Investigation Board; FRMS: Fatigue Risk Management System; OFER: Occupational Fatigue Exhaustion Recovery; DOE: Department of Energy; CI: Confidence Interval; AF: Acute Fatigue; CF: Chronic fatigue; HP: Human performance; SD: Standard deviation.

Ethics Approval and Consent to Participate

The Ethics Review Board of Universitas Indonesia examined and approved this study with the number Ket-658/UN2.F10.011/PPM.00.02/2020.

Competing Interest

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

Availability of Data and Materials

The raw data and output SPSS obtained from the study are available and kept by the corresponding author.

Authors' Contribution

AD and BW conceptualized the theories related to fatigue, human performance, and major oil and gas incidents. AD and BW also prepared the administered survey questionnaire and analyzed the results using statistic computation software. Both authors drafted this full manuscript.

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The authors declare that this paper has no sponsor.

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Effectiveness of Using Information, Education, and Communication Flowchart Media in Implementation of Early Breastfeeding Initiation

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Abstract

Early initiation of breastfeeding (EIB) has many benefits for both the baby and the mother. However, in Bogor City, there are still many babies who do not get EIB when they are born (33.6%). The implementation of EIB is not optimal due to the absence of standard procedures to equalize its theory and perception. This study aimed to investigate the effectiveness of using Information, Education, and Communication (IEC) flowchart media concerning the standard procedure for EIB implementation in the Primary Health Care (PHC) in Bogor City. A quasi-experimental research was conducted on 58 midwives divided into the intervention and control groups. The intervention group was given IEC flowchart media, the EIB standard procedure, whereas the control group was given a brief explanation about EIB. The results indicated that the intervention group (96.0) had a higher average EIB implementation score than the control group (84.7). Furthermore, the success rate of EIB was higher in the intervention group (93.1%) than in the control group (20.7%). In conclusion, the IEC flowchart media is effectively used to optimize EIB implementation by midwives in the PHC in Bogor City.

Keywords: early initiation of breastfeeding, flowchart, information, education and communication media, standard procedure

Introduction

The infant mortality rate is an important indicator of public health and quality of life in a country. The most vulnerable stage of child survival is the neonatal period, 28 days after birth, and has the highest risk of death.[1] Two-thirds of neonatal deaths occur during the perinatal period, 0–7 days after birth.[2] The global data indicates that the infant mortality rate in the world tends to decline from 37 deaths per 1000 live births to 18 deaths per 1000 live births during 1990–2017.[3] Furthermore, the World Health Organization (WHO) stated that the neonatal mortality rate of the Southeast Asian regions is 14 per 1000 live births. In Indonesia, the neonatal mortality rate in 2017 was 12.4 per 1000 live births.[4] This figure is still relatively high compared to several other countries in other Southeast Asian regions.

Neonatal mortality rates are closely related to infectious diseases caused by bacteria or parasites, such as respiratory tract and gastrointestinal infections. The disease can be prevented by administering colostrum immediately after giving birth through early initiation of breastfeeding (EIB).[5,6] The EIB is one of the interventions that can reduce the risk of neonatal death and make exclusive breastfeeding successful.[7-9] The EIB also prevents hypothermia in newborns,[10] and can reduce the risk factors for neonatal mortality by 22%,[11]; it also increases the chance of exclusive breastfeeding by eight times for up to 4 or 6 months compared with no EIB. In addition, EIB can strengthen the bond between the mother and the baby,[12] and help the mother prevent pre-lacteal feeding.[13]

The global prevalence of children below six months being exclusively breastfed is 43%, and 55% of newborns do not undergo EIB in the first one hour of life.[14] In Indonesia, the scope of exclusive breastfeeding of children below six months decreased 54% in 2016 to 46.7% in 2017; moreover, the EIB coverage was less than one hour in 2017 was 51.3%, and those who did not do EIB by 42%.[15] The role of midwives during childbirth is very vital. The support midwives give to pregnant women will determine the success of EIB implementation and exclusive breastfeeding, especially midwives working in primary health care (PHC).[16,17]

The presence of midwives is an important factor in the successful implementation of EIB.[18] The provision of midwife support to pregnant women was found to increase the success of EIB implementation by 17.5

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times.[19] The first hour after birth is crucial for midwives to perform EIB. The implementation of EIB is successful if it is carried out as soon as possible after delivery, and the process lasts for 60 minutes or more. During breastfeeding, the baby is placed on the mother's chest, and the midwife should ensure that the baby comes into skin-to-skin contact with the mother, finds the nipple, and drinks colostrum from the mother or the breast milk that first comes out.[10]

The Indonesian Midwives Association has established 58 steps for the Normal Childbirth Care program, in which EIB is included in the sequence of procedures, e.g., in step 43. However, in practice, not all midwives perform EIB optimally. According to Legawati,[20] some midwives who did not practice EIB had several reasons: impatience, need for more time, and difficulty implementing EIB. Currently, in Indonesia, EIB is confusing not only for health workers but also for the community. Information, Education, and Communication (IEC) media regarding EIB has not yet been provided optimally; thus, postpartum mothers do not know about EIB.[21,22]

The implementation of EIB in some health facilities is not optimal and is still hampered by many factors. The standard operating procedure of providing support to the EIB implementation is still limited.[9,23] Furthermore, the PHC has not yet set a standard procedure to equalize the perception between the theory and the implementation of EIB; thus, health workers only provide EIB services according to their individual abilities. The implementation of EIB by midwives in healthcare facilities, especially in hospitals and other health centers, is still inadequate; some midwives still perform EIB not following the existing stages.[24,25]

In 2018, IEC media was developed in the form of a flow chart regarding the procedure for the EIB implementation (hereinafter referred to as "IEC flowchart media of EIB").[26] The result of the study conducted in six PHCs in East Jakarta indicated a significant difference in the EIB implementation scores between the group given the information, education, and communication (IEC) flowchart media and the control group. The intervention group had a better score of 97.4 (84.4–100.0) than the control group with 78.3 (71.9–90.6). The use of this media also increased the implementation of EIB by midwives by up to 95.2%.[26]

The Health Profile of West Java in 2016 revealed that the coverage of exclusive breastfeeding in the West Java Province was 46.4%, whereas that in Bogor City was 53.3%.[27] Based on the National Basic Health Research/*Riset Kesehatan Dasar* (Riskesdas) data in 2013, the percentage of EIB implementation in less than one hour in the West Java Province was only 35.7%. In contrast, the EIB coverage in PHC in Bogor City was 33.6%.[28] This study aimed to determine the differences in the score of the EIB implementation between the intervention and control groups and confirm the effectiveness of using the IEC flowchart media,[26] in improving the implementation of EIB in the PHC in Bogor City.

Method

This study adopted a quantitative and quasi-experimental research design. It was conducted in February-June 2018 on 58 midwives from eight PHCs in Bogor City. Each group consisted of 29 midwives selected via purposive sampling based on subjective and practical considerations following the predetermined criteria. The inclusion criteria were as follows: 1) having experience assisting with childbirth during the study period and 2) having a midwifery diploma. The intervention group consisted of midwives who served at the Tanah Sareal PHC, Pasir Mulya PHC, Cipaku PHC, and Merdeka PHC. The control group consisted of midwives from the East Bogor PHC, Central Bogor PHC, North Bogor PHC, and Tegal Gundil PHC.

This study used a questionnaire to determine the age, educational background, work period, training, and knowledge of midwives; assessment form and IEC media were the additional instruments used. The participants in the intervention group received education in the form of IEC media containing a flowchart of the EIB implementation procedure printed on a poster and booklet with the registration numbers Intellectual Property Rights (IPR) 10417/UN2.F10.D/PPM.00.01/2018 and 10416/UN2.F10.D/PPM.00.01/2018, respectively. The participants in the control group, which was a comparison group, received education and a brief explanation about EIB but did not receive the IEC flowchart media.

In this study, the EIB implementation is considered successful if the baby can reach the mother's nipple and suckle until they are satisfied and falls asleep without intervention according to the procedure. The EIB score was obtained from the EIB implementation assessment form. Data collection was performed by 12 enumerators who were previously trained about the standard procedure of EIB and how to retrieve data in the field. All of the enumerators had a midwifery education background. Each enumerator must be in the PHC for 24 hours (standby) with a shift system adjusted to each PHC to assess the EIB implementation by midwives at the time of delivery.

Descriptive statistics were used to determine the respondents' characteristics (age, educational background, work period, training, and knowledge of midwives). An independent t-test was employed to determine the difference between the EIB score and the EIB success category in the intervention and control groups. The linear regression method was employed to determine the effect of independent variables on the EIB implementation.

Results

Table 1 presents an overview of the respondents' characteristics. In the intervention group, most of the respondents were ≤ 35 years old, had a Diploma-III (DIII) education, had worked for 12 years or less, and attended training related to EIB. Statistically, no significant differences were observed in the characteristics of the midwives between the two groups, except for knowledge. The control group respondents had better knowledge than the intervention group.

Table 2 compares of the average EIB implementation score between the intervention and control groups. The Independent t-test results indicated a significant difference in the EIB implementation score between the intervention and control groups. Table 2 demonstrates that the average EIB implementation score of the intervention group was higher (96.0) than that of the control group (84.7). The minimum and maximum scores obtained by the intervention group were also higher (87.5–95.0) than that of the control group (78.1–93.8). In the intervention group, 62% of the respondents scored more than 95.0, whereas, in the control group, the majority scored 87.5.

In general, the number of midwives that successfully performed EIB was higher in the intervention group (93.1%) than in the control group (20.7%). This study also demonstrated the successful implementation of EIB; in the intervention group, 65.5% of the midwives successfully performed EIB within one hour. After the first hour had passed, an increase of 26.7% in the success of the EIB implementation in the intervention group was observed, whereas there was no increase in the control group (Table 3).

The result of the multivariate analysis indicated that 63.6% of the successful EIB implementations were influenced by the use of the IEC flowchart media, age, education, work period, and training. In contrast, other factors influenced the rest (36.4%). The test results also revealed that the IEC flowchart media was the most dominant factor in implementing EIB, with a p-value of less than 0.05. The use of the IEC flowchart media increases the success rate of the EIB implementation by 11 times (Table 4).

Discussion

The characteristics of the respondents in the interven-

Table 1. Distribution of Respondents by Age, Education, Work Period, Training, and Knowledge to the Intervention and Control Groups

Variable	Category	Intervention Group		Control Group		p-value
		n = 29	%	n = 29	%	
Age	>35 years old	9	31	14	48.3	0.186
	≤35 years old	20	69	15	51.7	
Education	DIV	5	17.2	10	34.4	0.139
	DIII	24	82.8	19	65.6	
Work period	>12 years	10	34.5	13	44.8	0.430
	≤12 years	19	65.5	16	55.2	
Training	Ever	18	62	12	41.3	0.119
	Never	11	38	17	58.7	
Knowledge	Good	8	27.6	20	69	0.001*
	Insufficient	21	72.4	9	31	

Note: *p-value<0.05, DIV = Diploma-IV, DIII = Diploma-III

Table 2. Early Initiation of Breastfeeding Implementation Score of the Intervention and Control Groups

Variable	Category	Intervention Group		Control Group		p-value
		n = 29	%	n = 29	%	
Average EIB score	Mean	96.0		84.7		<0.000*
	95% CI	94.6 – 97.4		82.7 – 96.7		
Respondent's score	78.1	0	0	6	20.7	
	81.3	0	0	7	24.1	
	84.4	0	0	3	10.3	
	87.5	2	6.9	8	27.6	
	90.6	2	6.9	1	3.4	
	93.8	7	24.1	4	13.8	
	96.9	9	31			
	100	9	31			

Notes: *p-value<0.05, CI = Confidence Interval, EIB = Early Initiation of Breastfeeding

Table 3. The Effect of the Use of the Information, Education, and Communication Flowchart Media on the Early Initiation of Breastfeeding Implementation

Variable	Category	Intervention Group		Control Group		p-value
		n	%	n	%	
EIB succession	Success	27	93.1	6	20.7	<0.000*
	No Success	2	6.9	23	79.3	
EIB succession time	Success in 1 hour	19	65.5	6	20.7	0.000*
	Success in 2 hour	8	27.6	0	0	
	Success in 3 hour	0	0	0	0	
	No success	2	6.9	23	79.3	
Total		29	100	29	100	

Note: *p-value<0.05, EIB = Early Initiation of Breastfeeding

Table 4. Factors Associated with Early Initiation of Breastfeeding

Variable	n	%	p-value	R^2	B-Coefficient
IEC flowchart media			<0.000*		11.2
Age			0.355		2.3
Education	58	100	0.247	0.636	1.7
Work period			0.343		2.3
Training			0.444		1.0

Notes: *p-value<0.05, EIC = Information, Education, and Communication

tion and control groups were relatively similar. There were no differences in the characteristics (age, education, work period, and training) between the two groups, except for the knowledge variable. The knowledge in the intervention group was initially lower than that in the control group. However, this study demonstrated that after using the IEC flowchart media, printed on poster and booklet, the success rate of the EIB implementation was higher in the intervention than in the control group. The use of the IEC flowchart media can facilitate midwives in implementing EIB.

The results of this study indicated the importance of the IEC flowchart media in the implementation of EIB by midwives. The IEC flowchart media was able to improve the skills of midwives in facilitating EIB after childbirth. Statistically, there was a significant difference in the average EIB implementation score between the intervention and control groups. This result was in line with the studies conducted by Palupi,[26,30] which indicated that there was a significant difference in the average EIB implementation score between the two groups. These findings were also supported by Gunawan,[29] who stated that the provision of health education provides better knowledge and understanding of EIB. Knowledge is one of the factors that tend to affect the expected behavior.[26] The use of the IEC flowchart media is expected to increase the knowledge of midwives and improve the ability of midwives to implement EIB.

The implementation of EIB is one of the steps in the Normal Childbirth Care program that the Indonesia Midwives Association has determined; thus, it needs to be performed. The IEC flowchart media is significantly effective in increasing the accuracy of the EIB implementation and the potential for EIB success in the first one hour of life of the newborns. The standard procedure for the EIB implementation in the form of a flow chart is able to reduce the complexity of the actual situation of EIB in the health service. Midwives can easily implement EIB because the steps are presented on the flowchart chronologically, in detail, and clearly according to the situation that occurs. Moreover, the midwives can easily see the flow chart when facilitating EIB. The IEC flowchart media succeeded in solving complex problems about implementing EIB through simple steps at each stage so that the midwives easily understood it.[30]

The results indicated a significant difference in the average EIB implementation score between the intervention and the control groups. The success rate of midwives in performing EIB in less than one hour was higher in the intervention group (93.1%) than in the control group (65.5%). The increased success of the EIB implementation within one hour may be due to the correct placement of the baby on the mother's chest, as stated in the IEC flowchart media, making it easier for the baby to find and suckle the mother's nipple.

The implementation of EIB is hindered by time constraints,[31,32] and other activities still need to be done, such as weighing the baby and immunizations.[33] In health services, with existing routines and patients, the midwives have limited time in assisting mothers with EIB; therefore, it is important for the midwives to establish conducive practices in performing EIB effectively after birth.[34] This study demonstrated that using the IEC flowchart media, the implementation of EIB became more effective and successful within one hour.

After the first hour had passed, there was still an increase in the number of babies who managed to find the mother's nipple and suckle in the intervention group,

while in the control group, there was no addition. This situation indicated that the IEC flowchart media could increase the success rate of the EIB because the stages were already displayed on the flowchart in detail, which facilitates the midwives in performing EIB. If the baby has not yet been able to suckle within the first hour, the EIB process should be continued by bringing the baby closer to the nipple and allowing skin-to-skin contact between the mother and baby for the next 30–60 minutes.

This study demonstrated that the IEC flowchart media was the most dominant factor in successful EIB implementation. This result indicated that using the IEC flowchart media could facilitate midwives in performing EIB. Furthermore, the IEC flowchart media provided clear and step-by-step guidance in addressing the complexities of the actual situation in the implementation of EIB in health services.

The possibility biases were due to the lack of understanding of the data collectors when answering the questionnaires. The enumerators were trained before entering the field to prevent the problems from happening. The scope of this study was limited to the field area of research, and further research is needed to confirm the benefits of the IEC flowchart media.

Conclusion

The results of this study indicate that the average EIB implementation scores of both groups are different. The group of midwives who received IEC flowchart media was significantly higher than midwives who did not receive IEC flowchart media. The success rate of the midwives who were given IEC flowchart media for the EIB implementation was also higher than that of the control group. The implementation of EIB by midwives can be improved through the provision of the IEC flowchart media installed or affixed in places where childbirth occurs so the midwives can easily see it.

Abbreviations

EIB: Early initiation of breastfeeding; IEC: Information, Education, and Communication; PHC: Primary Health Care; WHO: World Health Organization; Riskesdas: *Riset Kesehatan Dasar*; IPR: Intellectual Property Rights; DIII: Diploma-III.

Ethics Approval and Consent to Participate

Ethics approval was obtained from the Faculty of Public Health Universitas Indonesia (No. Ref. 61/UN2.F10/PPM.00.02/2019). All of the respondents could refuse to participate in the study and were given an agreement form before filling in the questionnaires.

Competing Interest

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

Availability of Data and Materials

Data and materials of this study can be obtained upon request.

Authors' Contribution

AFF designed, conceptualized, collected, and analyzed the data of the study. RN was involved in the writing of the manuscript while SF directed and supervised this study right from the beginning, overviewed, and gave final approval to the manuscript.

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Aminolevulinic Acid Dehydratase Allelic Frequency and Lead Toxicity in Children Under-Five in a Former Used Lead-Acid Battery Area

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Abstract

Polymorphisms in the *Aminolevulinic Acid Dehydratase* (*ALAD*) gene responsible for the *ALAD1* and *ALAD2* alleles have been implicated in susceptibility to lead toxicity. This study aimed to determine the allelic frequency of *ALAD2* among children living in Bogor District, Indonesia, and its association with blood lead levels (BLLs) and lead toxicity. A cross-sectional study involving 128 children was conducted during September-October 2019 in the former ULAB area in Cinangka Village. The *ALAD* polymorphism, BLLs, and hematological parameters were evaluated. Blood samples were taken for dried blood spotting on filter paper, blood film, and BLL measurement. The PCR amplification and sequencing of the genomic DNA revealed the presence of two forms of the *ALAD2* allele: 177C and 177T with a frequency of 0.05. Analysis of the correlation between the *ALAD2* allele, BLLs, and basophilic stippling revealed that *ALAD2* carriers had a five times higher risk of high BLLs, (OR = 5.359, p-value = 0.155) and had a slightly higher risk of exhibiting basophilic stippling (OR = 1.09, p-value = 1.000). Although not statistically significant, these findings suggested that the *ALAD* genotype may modify BLLs and lead to toxicity. The *ALAD2* allele (177T) is firstly reported in any population in the world.

Keywords: *Aminolevulinic acid dehydratase-2* allele, basophilic stippling, blood lead level, lead toxicity

Introduction

Lead is one of the ten most dangerous chemicals for humans.[1] Long-term lead exposure was responsible for 1.06 million deaths and 24.4 million disability-adjusted life years (DALYs) worldwide in 2019.[2] The burden was the greatest in low- and middle-income countries (LMICs). Exposure to lead can occur through contaminated air, water, dust, food, or consumer products.[1] The amount of lead in blood and tissues, as well as the time course of the exposure, determine its toxicity.[3] Lead poisoning can cause various symptoms and signs, depending on the individual and the duration of lead exposure.[4] Early-life exposure to lead can re-program genes, resulting in altered gene expression and a higher risk of disease later in life.[5]

Young children are the most vulnerable to lead poisoning because they are more likely to put objects in their mouths, such as those containing lead paint, and absorb a greater proportion of lead.[1,6] Exposure at work is a common cause of lead poisoning in adults with certain occupations at high risk.[7] Poisoning with large doses of lead damages the brain and central nervous system, resulting in coma, convulsions, and even death. Children who survive severe lead poisoning may develop intellectual disabilities as well as behavioral problems. At low levels of exposure that create no evident symptoms, lead has been shown to impair children's brain development, resulting in lower intelligence quotient (IQ), behavioral changes such as decreased attention span and increased antisocial behavior, and poor educational attainment. Symptoms of lead poisoning include anemia, hypertension, renal impairment, immunotoxicity, and toxicity to the reproductive organs. Lead is thought to have irreversible neurological and behavioral consequences.[1]

Lead poisoning can occur in the presence of erythrocyte inclusion objects.[8] Lead can cause erythrocyte hemolysis and inhibit the formation of hemoglobin. Lead also causes the enzyme glucose-6-phosphate dehydrogenase (G-6PD) deficiency and inhibits the enzyme pyrimidine-5'-nucleotidase. This causes a reduction in the life span of erythrocytes and increases the fragility of the erythrocyte membrane, thus reducing the number of ery-

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throcytes.[9] A deficiency in this enzyme is hereditarily characterized by basophilic stippling on erythrocytes. Previous studies have also shown that lead inhibits haem biosynthesis by inhibiting the enzyme's coproporphyrinogen, *δ-aminolevulinic acid dehydratase* (*ALAD*), and ferrochelatase which reduces hemoglobin (Hb) levels in the blood.[10,11] The presence of lead in erythrocytes causes disruption of hemoglobin formation in erythrocytes. Furthermore, basophilic stippling in erythrocytes indicates a change in blood morphology, which shows that there has been disruption of haem synthesis in children due to lead exposure, although it did not cause anemia.[12] Only lead exposure levels above 50 µg/dL for adults and 25-40 µg/dL for children can cause basophilic stippling and microcytic or normocytic anemia.[13]

The Center for Disease Control (CDC) has set an upper limit for blood lead exposure for adults and children: 10 µg/dL (10 µg/100 g) and 5 µg/dL, respectively.[14] Elevated lead levels may be diagnosed by measuring the blood lead levels (BLLs).[1] Changes in levels or dense lines in the X-ray of children's bones can also be used to detect elevated lead levels.[15] Human hair might be employed as an alternative matrix to identify chronic lead exposure.[16] The δ-aminolevulinate dehydrase (5-aminolevulinate hydrolase, EC 4.2.1 .24, ALADH) is an enzyme of the haem biosynthetic pathway which catalyzes the condensation of two molecules of δ-aminolevulinic acid to form a monopyrrole ring of porphobilinogen.[17] In humans, this enzyme is coded for by the *ALAD* gene located on chromosome 9q34.[18]

Previous studies have shown that *ALAD* gene polymorphisms and lead toxicity have a relative relationship with BLLs.[19-21] The *ALAD2* allele is associated with lead liver and kidney toxicity and damage to the hematopoietic system.[22] The prevalence of the *ALAD2* allele ranges from 0 to 20%, depending on the population. Generally, Caucasians have the highest frequency of the *ALAD2* allele, with approximately 18% of the Caucasian population being *ALAD1/2* heterozygotes and 1% being *ALAD2/2* homozygotes. In comparison, African and Asian populations have low frequencies of the *ALAD2* allele, with few or no *ALAD2* homozygotes being found in such populations.[23] In Indonesia, previous studies documented markedly different results regarding *ALAD* genotype frequencies. Firdausi, *et al.*,[24] reported the frequency of polymorphism in *ALAD* genes in the population of 60 elementary school students in Kalideres Subdistrict, West Jakarta Administrative City. They found an *ALAD1/1* frequency of 51.7% and *ALAD1/2* frequency of 48.3% and did not find any *ALAD2/2* homozygous individuals. Rujito, *et al.*,[25] found 91.8% of *ALAD1/1* and 8.2% *ALAD1/2* and did not find any. *ALAD2/2* individuals among 67 gas station workers aged 20–60 years from seven gas stations in Banyumas District. Shen, *et al.*,[26] studied the gene distribution of the *ALAD* isozyme phenotypes in 229 children aged 6–10 years who live within a community in which a large smelter is located; they found *ALAD1/1* (92%), *ALAD1/2* (8%), and *ALAD2/2* (0%). Diawara, *et al.*,[27] reported that among 231 children who lived next to smelting activities in Pueblo, Colorado, the United State of America, 94.4% of children had *ALAD1/1*, 5.6% had *ALAD1/2* polymorphisms, and none had *ALAD1/1* polymorphism.

Lead-acid batteries, also called car batteries, are rechargeable batteries in which lead plates in sulfuric acid are enclosed in a plastic shell. They are utilized in every country on the planet. The batteries can be recharged several times, but after several cycles, the lead plates degrade, and the battery's ability to store energy for any length of time is lost. When a lead-acid battery stops working, it becomes unusable and is designated as a used lead-acid battery (ULAB), which is a hazardous waste under the Bassel Convention.[28]

Since 1978, Cinangka Village in Bogor District has been known as a center for ULAB recycling. This illegal anthropogenic activity aims to obtain lead blocks, resold as raw materials for various industries. Unfortunately, the recycling technology used is very simple. Thus, it poses a health risk and leads to environmental pollution. This illegal activity has been closed several times; however, people still secretly carry out these illegal activities behind their homes, where their children usually play. In 2014, in collaboration with Blacksmith, an American non-governmental organization (NGO), the Ministry of the Environment of the Republic of Indonesia carried out remediation of lead-contaminated land in Cinangka Village. However, these efforts have only recovered ~10% of the total lead-contaminated land in Cinangka Village. By the end of 2018, through the National Defense Council, the government again issued strict instructions regarding the prohibition of ULAB recycling in Cinangka Village. Thus, the authors of this study aimed to analyze the current condition of children in Cinangka Village after ULAB recycling was prohibited in the area. This study was done to determine the allelic frequency of *ALAD2* among children who lived near former ULAB recycling areas and chose its association with BLLs and lead toxicity. By knowing the *ALAD* gene profile in children, information about individual susceptibility to lead exposure can be obtained.

Method

Cinangka Village is located at an altitude of 286 m above sea level and is in the Ciampea Subdistrict, Bogor District. This village has an area of 3.4 km^2 or ~11.10% of the area of the Ciampea Subdistrict. A total of 4,195 households are spread over ten hamlets.[29]

Based on information from local officials, of the 13,253 people living in Cinangka Village, 1,204 were children below five years old in 2021. The study sample consisted of 147 children who met the inclusion criteria: aged 1-5 years, with parents who lived in the study area for three years and agreed that their children were respondents. Samples were taken using a purposive sampling technique, and the study was carried out in four selected hamlets/*Rukun Warga* (RW) because high-intensity ULAB activities had previously occurred in these locations. Samples were taken by cluster: samples of 33 children were taken from hamlet 01, 71 from hamlet 03, 27 from hamlet 04, and 16 children from hamlet 06.

The sample size was calculated based on the Formula 1. The P_1 is the proportion of the *ALAD* allele that had undergone polymorphism in the lead-exposed group. At the same time, P_2 is the proportion of *ALAD* alleles that had undergone polymorphism in the lead-unexposed group. The value of the proportion of ALAD alleles in the lead-exposed and unexposed groups was obtained from the results of previous studies.[19,30] In the calculation, the level of significance (α) was set at 5% or $Z_{1-\alpha/2}$=1.96, and the power of the test (1-β) was 80%. Therefore, the study required a minimum of 132 children to test the hypothesis of two population proportions. The sample sizes were increased by 10% to account for dropouts. The purposive sampling method recruited 147 children from different households. Of these, the blood of only 128 children was genetically analyzed, making this the total final sample for this study.

Three variables were evaluated: *ALAD* gene, BLLs, and basophilic stippling. Briefly, blood sampling was carried out on October 17-18, 2019, at the local village office. Integrated Service Post/*Pos Pelayanan Terpadu* (*Posyandu)* cadres helped arrange the arrival of the children with their mothers for blood collection. Each child's arm was cleaned with soap and water, dried with a tissue, wiped with an alcohol swab, and dried with gauze before drawing peripheral blood by phlebotomists. The blood lead level was measured using the LeadCare® II Portable Analyser. Rapid in situ diagnosis can be performed in less than three minutes with the LeadCare® II Portable Analyser. The analyzer expressed blood test results in µg/dL.

Deoxyribonucleic acid (DNA) was extracted from the dried blood spot using the Chelex method.[31] The DNA obtained was used as a template for polymerase chain reaction (PCR) amplification of the *ALAD* gene using the following oligomers: forward primers (5′-AGACAGACATTAGCTCAGTA-3′ and reverse primers: 5′-GGCAAAGACCACGT CCATTC-3′),[30] under the following conditions: 45 cycles of initial denaturation at 94°C (5'), followed by denaturation at 94°C (30"), annealing at 54°C (30"), and extension at 72°C (1') followed by a final extension at 72°C (4'). The amplicon obtained was verified on the agarose gel. If positive, the amplicons were prepared for DNA sequencing to identify the presence of the polymorphism at nucleotide 177 of the *ALAD* gene. The presence of the *ALAD* gene was indicated by the appearance of a band located parallel to the positive control. The normal allele PCR product was the *ALAD* gene allele, which is in the 917-bp band.

$$n = \frac{\left\{z_{1-\alpha/2}\sqrt{2\,\bar{P}\,(1-\bar{P})} + z_{1-\beta/2}\sqrt{P_1\,(1-P_1) + P_2\,(1-P_2)}\right\}}{(P_1 - P_2)^2}$$

Formula 1. Sample Size Calculation

The polymerase chain reaction (PCR) products were purified using clean-up systems (PROMEGA Corporation, Madison, WI, USA) and Exonuclease I shrimp alkaline phosphatase (USB, Affymetrix, Cleveland, OH, USA). The purified amplicons were sequenced using an ABI Prism Dye Big Dye Terminator Cycle Sequencing Ready Kit (Applied Biosystem, Foster City, CA, USA) in a fluorescent DNA capillary electrophoresis sequencer (ABI 3130×l). The analysis was done at the Eijkman Institute (Jakarta, Indonesia). In case of ambiguity in sequencing reading, sequencing was repeated in both directions (forward and reverse primers).

The PCR method was validated by testing the reproducibility and specificity parameters of the PCR product. The PCR method met the reproducibility parameters if the same electropherogram was produced at 917-base pair (bp) from the PCR product of different DNA isolate samples. The PCR method met the specificity parameters if the nucleotide sequence of the PCR product at 917 bp matched the Genbank nucleotide sequence of the *ALAD* gene. Specificity was determined by sequencing the PCR product, and sequencing results were manually edited using the BioEdit program. The resulting nucleotide sequence was aligned with the *ALAD* gene sequence from GenBank using Clustal W, a part of the BioEdit program. Thin blood smears stained with Giemsa were identified for the presence of basophilic stippling using light microscopy (objective 1000x).

Chi-Square analysis was performed to evaluate the Hardy–Weinberg balance in the allelic distribution and identify the relationship between *ALAD* gene polymorphisms and the respondent's BLL. A p-value of less than 0.05 was considered statistically significant to verify the relationship between the *ALAD* gene polymorphism and the respondent's BLLs. The value of X^2 indicated the Hardy–Weinberg balance compared to the critical p-value of 0.05 (df = n-1) in the Chi-square table (there is no

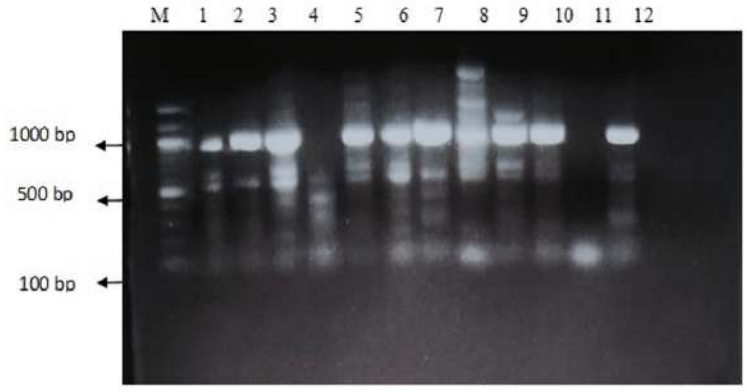
difference in the frequency of the *ALAD* gene allele in the population). If the value of X^2 is less than critical value, there is a Hardy–Weinberg balance. Chi-square analysis was also used to evaluate the relationship between *ALAD* gene polymorphisms and the respondent's BLL and basophilic stippling.

Results

Respondents were children aged 1–5 years whose parents had lived permanently in Cinangka Village for a minimum of three years. The children were selected due to the high susceptibility of lead exposure from the environment and the relatively low mobility compared to adults. A minimum exposure time of three years was used in study because environmental lead exposure occurs chronically in small doses; thus, a long time is required to accumulate in the body.

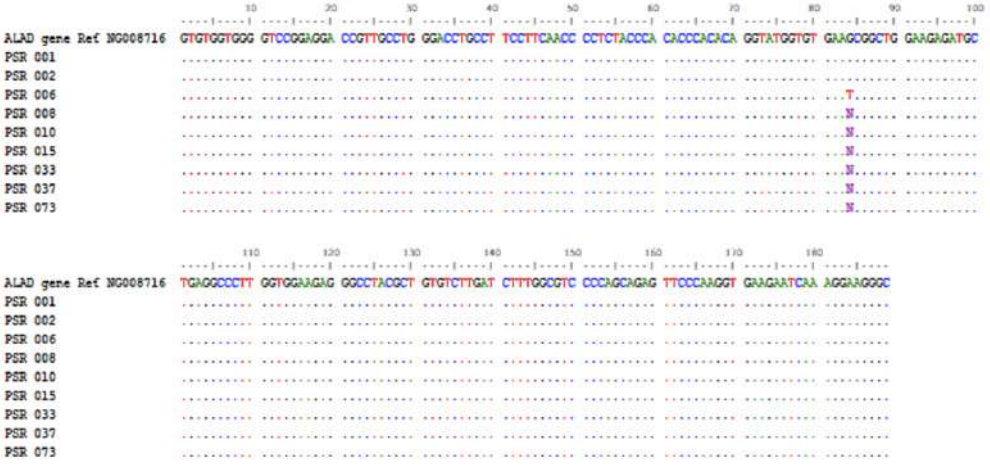
The PCR amplification of DNA samples extracted from 128 individuals yielded an amplicon of the expected size of 917 bp (Figure 1). The amplicon obtained was then purified and prepared for DNA sequencing.

The DNA sequencing results were aligned using the BioEdit Programme and compared with standard published sequences (Figure 2). Based on the polymorphism at nucleotide 177, the *ALAD2* allele was found in two forms (177C and 177T), in which the asparagine (N) residue is substituted by lysine (K) at codon 59 of the *ALAD* gene (Figure 3). The *ALAD* genotype frequency was *ALAD1/1* (90.6%), *ALAD1/2* (8.6%), and *ALAD2/2* (0.8%). The allelic frequencies of *ALAD1* and



Notes: Marker (M) 100 bp; Ladder (Lane 1-12); Sample No. 005, 006, 015, 017, 018, 021,037, 047, Negative Control, and Positive Control

Figure 1. PCR Products of *ALAD* Amplification with the 917-bp DNA Target



Notes: N in Sample PSR 008, 010, 015 = G/T; N in Sample PSR 033, 037, 073 = G/C

Figure 2. Alignment of DNA Sequencing Results of the *ALAD* Gene Fragment Encompassing Nucleotide 177

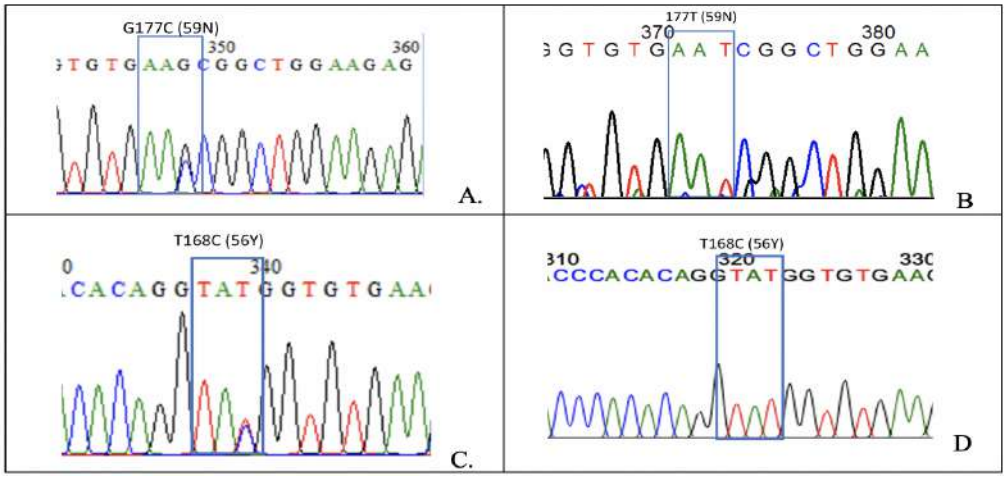


Figure 3. Electropherogram of the DNA Sequencing Results of the *ALAD* Gene Fragment Flanking Nucleotides 177 and 168

Table 1. Genotype Distribution of the Allelic Frequencies in the Study Population

ALAD Genotypes	n (Obs.)	Genotype Frequency	n (Exp.)	Allele Frequency
1-1 (GG)	116	0.906	115.33	*ALAD1* = 0.95
1-2 (GC/GT)	11	0.086	12.34	*ALAD2* = 0.05
2-2 (TT)	1	0.008	0.33	X^2 = 1.51
				df = 1; p-value>0.05
	128	1.000	128	(Critical value = 3.84)

Notes: *ALAD* = *Aminolevulinic Acid Dehydratase*, df = degree of freedom, Obs. = Observed, Exp. = Exposed

Table 2. Correlation of the *Aminolevulinic Acid Dehydratase-2* Allele with Blood Lead Levels

ALAD Allele	Blood Lead Levels						OR	95% CI	p-value
	High		Low		Total				
	n	%	n	%	n	%			
ALAD2	11	91.7	1	8.3	12	100	5.359	0.667–43.047	0.155
ALAD1	78	67.2	38	32.8	116	100			

Notes: *ALAD* = *Aminolevulinic Acid Dehydratase*, OR = Odds Ratio, CI = Confidence Interval

ALAD2 were 0.95 and 0.05, respectively (Table 1).

Comparison of the Chi-square results with the critical value showed that no difference existed in the frequency of the *ALAD* gene in the population over generations, which indicates that the Hardy–Weinberg equilibrium was established. In addition, a non-synonymous nucleotide substitution from C to T at base 168 of the *ALAD* gene was also found in 19 samples. This nucleotide substitution does not introduce any amino acid changes.

Analysis of the correlation between the *ALAD2* allele and BLL using Chi-square revealed that subjects carrying the *ALAD2* alleles had 5.3 times higher risk of having a high BLL (Table 2). However, the results were not statistically significant (p-value = 0.155). Analysis of the correlation between the *ALAD2* allele and basophilic stippling revealed that subjects carrying the *ALAD2* allele had a slightly higher risk of experiencing basophilic stippling (OR = 1.09, p-value = 1.000) (Table 3).

Discussion

The frequency distribution of the *ALAD1* and *ALAD2* alleles among different populations worldwide has been the subject of numerous investigations. These studies have used genotype and phenotype techniques and indicated that the *ALAD2* frequency ranges from 0 to

Table 3. Correlation of the *Aminolevulinic Acid Dehydratase-2* Allele with Basophilic Stippling

ALAD Allele	Basophilic Stippling						OR	95% CI	p-value
	Yes		No		Total				
	n	%	n	%	n	%			
ALAD2	3	25.0	9	75.0	12	100	1.0941	0.278–4.305	1.000
ALAD1	31	26.72	85	73.28	116	100			

Notes: *ALAD* = *Aminolevulinic Acid Dehydratase*, OR = Odds Ratio, CI = Confidence Interval

20%.[18,23,32-34] The *ALAD2* allelic frequency among different populations of Indonesia had been previously reported in several studies. Using the PCR-ARMS technique, Firdausi, *et al*.,[24] reported an *ALAD1/1* frequency of 51.7% and an *ALAD1/2* frequency of 48.3% without any *ALAD2/2* individuals in the population of 60 elementary school students in Kalideres Subdistrict, West Jakarta Administrative City. Another study reported an *ALAD1/1* frequency of 91.8% and an *ALAD1/2* frequency of 8.2% without any *ALAD2/2* individuals among 67 gas station workers in Banyumas District using the PCR-RFLP technique.[25] Using PCR DNA sequencing, this study found an *ALAD2* allelic frequency of 0.05 (same frequency as that observed in China,[32]), and surprisingly, a novel form of the *ALAD2* allele (177T) was discovered. This novel form has never been reported previously in any *ALAD* gene population study worldwide, and previous studies have only reported a G→C transversion for *ALAD2* allele polymorphism.[19,35] This finding might explain why a significantly different result was reported in previous studies that did not use PCR DNA sequencing. The DNA sequencing method can detect all nucleotide sequences in the target region of the *ALAD* gene so that previously undetected polymorphisms can be identified. Therefore, the frequency distribution of the *ALAD* gene in previous studies that have not included the T allele in their calculations can be revised. Based on the published *ALAD2* frequency among the Asian population, the finding of this study may be more reliable and valid.[23]

The *ALAD* G177C polymorphism yields two codominant alleles, *ALAD1* and *ALAD2*, and it has been implicated in the susceptibility to lead toxicity. The rarer *ALAD2* allele has been associated with high BLLs and has been thought to increase the risk of lead toxicity by generating a protein that binds lead more tightly than the *ALAD1* protein.[23] A G→C transversion occurs at position 177 of the *ALAD2* coding area resulting in the replacement of asparagine for lysine at amino acid 59. These two alleles give rise to three isozymes—1/1, 1/2, and 2/2—which all have identical functions but differ in charge. Asparagine is a positively charged amino acid, whereas lysine is neutral. Thus, *ALAD1/2* heterozygotes create a more electronegative enzyme than *ALAD1* homozygotes, whereas *ALAD2* homozygotes produce a more electronegative enzyme than 1/2 heterozygotes.[23] Analysis of the correlation between the *ALAD2* allele and BLL in this study indicated the higher risk of having high BLL among subjects carrying the *ALAD2* allele. However, the result was not statistically significant. Similar findings have been reported previously in numerous population studies, particularly those living under higher lead exposure.[22,26,35] No association was observed between *ALAD2* and BLL, perhaps because the *ALAD* genotype might be a modifier of BLL only at high BLL concentrations.[35] Although this study did not find an association between the *ALAD2* allele and BLL, the mean BLL among *ALAD2* carriers was higher (29.41 µg/dL) than that among *ALAD1* carriers (17.14 µg/dL). This result proved that *ALAD2* could bind lead better than *ALAD1*.

Concerning the association between the *ALAD2* allele and basophilic stippling, this study found an unexpectedly different result in which *ALAD2* allele carriers only had a slightly higher risk of basophilic stippling in their erythrocytes. However, the result was not statistically significant. Previous studies have reported that basophilic stippling, particularly among children, is a clear sign of lead toxicity.[36] In this study, no association was observed between *ALAD2* and basophilic stippling. Similar to the relationship of *ALAD2* with BLL, this was possible because the association only occurs at high BLLs, which affected *ALAD2* activity. In addition, although it was found that children's BLL level in Cinangka Village exceeded the measurement limits of the LeadCare® II instrument (>65.0 µg/dL), because there were only two respondents, the available data were not representative enough to be analyzed statistically. Therefore, the insufficient number of samples was a limitation of this study, as did the absence of a control group. Further studies to explore the frequency of *ALAD* polymorphisms and its association with BLL and lead toxicity among different populations are required with an adequate number of samples.

Conclusion

The allelic frequency of *ALAD2* among children living in Cinangka Village, Bogor District, is 0.05. Although not statistically significant, this study suggests that the *ALAD* genotype may modify BLLs and lead to toxicity. The *ALAD* genotyping method using PCR-sequencing can be applied for the detection of *ALAD* gene polymorphism in children with more precise results. Identifying the *ALAD* gene can be used as a screening tool for individual susceptibility to lead exposure. Further studies regarding the pathogenesis and pathophysiology of lead intoxication are needed to determine its relationship with *ALAD* gene polymorphisms.

Abbreviations

ALAD: Aminolevulinic Acid Dehydratase; BLL: Blood Lead Level; DALYs: Disability-Adjusted Life Years; LMICs: Low- and Middle-Income Countries; IQ: Intelligence Quotient; Hb: Hemoglobin; µg/dL; microgram per deciliter; CDC: Centers for Disease Control and Prevention; ULAB: Used Lead-Acid Batteries; NGO: Non-Governmental Organization; RW: *Rukun Warga*; Posyandu: *Pos Pelayanan Terpadu*; DNA: Deoxyribonucleic Acid; PCR: Polymerase Chain Reaction.

Ethics Approval and Consent to Participate

The study protocol was reviewed and approved by the ethical committee of the Faculty of Public Health, Universitas Indonesia (404/UN2.F10/PPM.00.02/2019). The parents were briefed about the protocol during the sampling process written informed consent before recruiting their children as participants of the study.

Competing Interest

The author declares that there are 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 data are fully available without restriction.

Authors' Contribution

YI is involved in design studies, data analysis, compilation, and preparation of journal publications. HK and UFA are involved in design studies. DS and PBSA are involved in drafting publication journals. AS assisted with lead reagent procurement, facilitating LeadCare® II tools, and providing lead-related materials. ASt involved in technical assistance in sampling procedures. RR was involved in technical assistance in sampling procedures and genetic analysis. S assisted in basophilic stippling examination, DHP, LS, FKD assisted in genetic analysis.

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Public Perception and Obedience with Social Distancing Policies during the COVID-19 Pandemic in Jakarta, Indonesia

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Abstract

The Indonesian Government established a social distancing policy to prevent COVID-19 transmission. However, this implementation will be ineffective without the compliance of the people. This study aimed to analyze the relationship between public perception and obedience with social distancing in terms of the variables based on the Health Belief Model. This study used a cross-sectional design with a population of *Daerah Khusus Ibukota* (DKI) Jakarta's indigenes within the productive age of 15-64 years. The sample comprised 408 participants, with the independent variables of sociodemographics (age, gender, occupation, and education) and health beliefs (perceived susceptibility, severity, benefits, barriers, and self-efficacy). Meanwhile, obedience to social distancing was the dependent variable. Data were obtained through an online questionnaire and evaluated with the bivariate and multivariate analysis using Chi-square and logistic regression tests. Gender (OR = 2.327; 95% CI = 1.404-3.857) and perceived self-efficacy (OR = 2.609; 95% CI = 1.726-3.945) were significantly related to social distancing obedience. Meanwhile, no statistical correlation (p-value>0.05) was found with sociodemographics, perceived susceptibility, severity, benefits, and barriers. The males with low self-efficacy were more likely to disobey the social distancing policies. The individual's self-efficacy perception increased with their level of obedience to social distancing policies.

Keywords: COVID-19, health belief model, obedience, public perception, social distancing

Introduction

During the pandemic, various countries, such as the United Kingdom (UK), the United States of America (USA), and the European Union, implemented preventive measures in the form of social distancing policies set globally by the World Health Organization (WHO).[1] These social restrictions were executed to minimize physical contact between communities with high and low transmission rates, individuals who are susceptible and non-susceptible, and to suppress the spread and transmission of coronavirus disease 2019 (COVID-19) in society.[2] The Australian Government Department of Health in 2020 stated that social distancing is essential because COVID-19 is spread through: (1) direct close contact with an infected person within 24 hours before symptoms occur; (2) close interaction with an infected and confirmed person, when they cough or sneeze, and; (3) touching body parts, such as the mouth and face after contact with objects or surfaces contaminated with coughs or sneezes from an infected individual. Furthermore, a distance between two individuals minimizes the virus circulation through air droplets from coughs, sneezes, or talks.[3]

According to the COVID-19 Task Force website data, five of the 34 provinces in Indonesia had the highest number of cases. These provinces included DKI Jakarta, East Kalimantan, West, Central, and East Java with 25.4%, 4.1%, 17. 0%, 11.0%, and 8.8% cases, respectively. Furthermore, DKI Jakarta Province, which was the epicenter of the COVID-19 spread, became the largest contributor to positive confirmed cases in Indonesia, with a total of 414,106 by May 9, 2021.[4] These high numbers of cases led the local government to take steps to establish various regulations and hence reduce the number of individuals who were confirmed to be positive. Since 2020, there have been more than fifteen regulations initiated by the DKI Jakarta Governor regarding social restrictions or distancing. According to the DKI Jakarta Governor's Regulation No. 3 of 2021, regarding the Regional Regulation implementation No. 2 of 2020

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concerning COVID-19 handling, activities conducted during social distancing in offices/workplaces, business places, industrial premises, hotels/other similar inns, and tourist attractions should be restricted. Also, education units, worship centers, transportation modes, food stalls, cafes, restaurants, street vendors, health care facilities, public areas, and other places with crowds should be regulated.[5]

Social distancing is a non-pharmaceutical intervention used to control respiratory tract infections by reducing social contact and increasing the distance between people.[6] Caitlin & Tom,[7] defined this phenomenon as a public health practice, which prevents people infected with a disease from interacting with healthy individuals to reduce the transmission risk. These practices include large-scale and individual actions, such as canceling large gatherings, closing public places, and avoiding crowds. During the pandemic, social distancing was used to slow the spread of the virus by reducing the probability of infection among the high-risk population.[8] Also, epidemiologists described this effort as a flattening curve, which refers to its potential success in preventing additional positive cases that burden the health care system.[9]

The COVID-19 study through the susceptible-exposed-infectious-quarantine-recovered (SEIQR) model in China showed that social distancing for 30 days significantly suppressed the number of cases in Wuhan and Hubei.[10] Another research in the UK suggested that implementing these policies by susceptible communities could reduce peak healthcare demand and deaths by 2/3 and a half.[11] Also, several modeling to observe the effectiveness of these preventive measures in South Korea and Japan indicated that the spread of the virus could be reduced.[12] Moreover, individual, organizational, and psychological factors influence obedience behavior. These individual factors include demographic characteristics, such as age, gender, education, years of service, and marital status. Meanwhile, the organizational aspects consist of human resources, leadership, and psychological factors, including attitudes, motivations, and perceptions.[13] According to the obedience theory developed by Kozier,[14] self-motivation, required style change level, health problems perception, knowledge, the impact of housing, culture, satisfaction level, and quality of health services received impact obedience behavior.

The Indonesian Government launched various initiatives, such as issuing regulations regarding the Large-Scale Social Restrictions (LSRR)/*Pembatasan Sosial Berskala Besar* (PSBB) implementation in DKI Jakarta Province, in response to the COVID-19 spread. This recommendation in the context of accelerating the COVID-19 handling was stated in the Health Minister of the Republic of Indonesia Regulation No. 9 of 2020.[15] In addition, LSSR involved closing schools and workplaces (work from home and school from home), restrictions on religious events, and activities in public places (social/physical distancing).[15] Also, obedience in implementing social distancing policies pertains to the DKI Jakarta Governor Regulation No. 3 of 2021 on the COVID-19 handling, where indigenes were restricted from participating in outdoor activities. These aspects involve keeping a distance from people in public places and transportation, such as offices/workplaces, academic units (schools/campuses), worship centers, restaurants/cafes, markets/pedestrians, and other public places that can generate crowds (wedding reception venues). Furthermore, individuals who fail to comply with these regulations and violations will be subject to sanctions, such as a maximum administrative fine of IDR 250,000 or social work by cleaning public facilities.[16]

The Health Belief Model (HBM) theory was used to view individual behavior in deciding health actions influenced by their beliefs/perceptions. From this concept, preventive actions were influenced by two assessments; the threat from the disease in the form of perceived susceptibility and seriousness and considering the advantages and disadvantages of taking these actions. Furthermore, six elements, including self-efficacy, cues to action, perceived susceptibility, seriousness, benefits, and barriers, trigger these issues in the HBM theory.[17] In 2003, severe acute respiratory syndrome (SARS) was an international public health threat. The Health Belief Model (HBM) has been used extensively to determine factors associated with an individual's practice of the target SARS preventive behavior (mask-wearing). It is found that perceived benefits, barriers, and cues to action have significant implications in enhancing the effectiveness of SARS prevention programs.[18]

However, studies regarding social distancing and factors influencing it among people in DKI Jakarta Province are still inadequate. The previous studies did not focus on people's perception and obedience to social distancing. For these reasons, the authors aimed to analyze the relationship between public perception of social distancing practice and people's obedience to social distancing policies. Thus, the study findings are beneficial for monitoring and evaluating social distancing policies in controlling the COVID-19 transmission.

Method

This study used a cross-sectional design to observe the level of social distancing obedience within DKI Jakarta Province in 2021. The independent variables included the people's sociodemographic characteristics (age, gender, education, occupation) and their perception of the HBM theory (susceptibility, severity, benefits, barriers, and self-efficacy). Meanwhile, obedience in complying with social distancing policies is the dependent

variable. This study included 400 participants aged 15-64 years and living in the DKI Jakarta Province area. Moreover, the respondent data was collected with an online questionnaire on the Google Forms platform and distributed using a purposive sampling method through social media, such as Line, WhatsApp, Twitter, and Instagram. The data was analyzed to assess the level of respondents' perception and behavior in a numerical score pattern.

All variables, such as age, gender, education, occupation, perception, and behavior, were categorized as binary. The age was grouped into 15-25 years (students) and more than 25 years (workers). These groups were divided based on the tendency to disobey social distancing policies. Respondents aged over 25 years (workers) tend to go to public places (go to the office) and use public transportation, while students still do activities from home. Gender was divided into male and female. Education was divided into low and high education based on respondents' latest education. Respondents with the latest education high school or below were categorized as low education, while respondents with the last education above high school were categorized as high education. The occupation was divided into non-students and students. This was based on the tendency to disobey social distancing policies, where students did not have to go to work (go out of the house) because all learning activities were currently done from home. In contrast, non-students had more tendency to mobilize/leave the house due to work demands.

The perception was divided into high and low based on a 'neutral' cut-off point. Respondents with a neutral-disagree answer were categorized into low perception, and respondents who answered agree-strongly agree were categorized into high perception. Social distancing behavior was divided into risky and non-risky behavior. Respondents who never go to public places/never use public transportation and always keep their distance when in public places/public transportation were categorized into non-risky behavior. The results were evaluated with bivariate (Chi-square) and multivariate (logistic regression) analysis. The Chi-square test was used to see the relationship between dependent and independent variables and the logistic regression test determined the independent variable with the most dominant effect on obedience with social distancing policies.

Results

Table 1 displays the results of the variables, where each question item was categorized into binary to produce a single variable. Subsequently, the perception factor was divided into low and high based on a neutral cut-off point. Meanwhile, the behavioral variables were divided into risky and non-risky. The non-risky referred to respondents who never visit public places, use public transportation, and always maintain a safe distance from others. Table 1 shows that the behavior frequency distribution of most respondents was risky. Furthermore, most perceived severity and benefits were high, while the susceptibility, barriers, and self-efficacy were low

The Chi-square test used to determine the statistical relationship between sociodemographic characteristics. The HBM constructs independent variables (perceived susceptibility, severity, benefits, barriers, and self-efficacy) and the dependent factors in the form of social distancing behavior. Furthermore, the relationship between the independent and dependent variables is termed meaningful if the p-value is less than α, in the statistical test using Chi-square with a significant degree of $\alpha = 0.05$. Table 2 shows that gender and self-efficacy variables had a significance of less than 0.05, where it indicates an association/relationship on the test criteria. Therefore, there is an association/relationship between gender and perceived self-efficacy with obedience in implementing social distancing.

The enter method was used in the logistic regression analysis, which included all the bivariate tested independent variables, such as age, gender, education, occupation, perceived susceptibility, severity, benefits, barriers, and self-efficacy. Subsequently, each variable was eliminated to produce a significant value of $\alpha<0.05$. The results of the logistic regression analysis are as in Table 3.

According to Table 3, gender and perceived self-efficacy had a statistically significant relationship with social distancing obedience (p-value$<\alpha = 0.05$). A p-value of 0.001 (OR = 2.327; 95% CI = 1.404-3.857) in males indicated a positive regression correlation; hence, males have 2.327 times more likely to engage in risky behavior when compared to females. Meanwhile, self-efficacy with a p-value<0.001 (OR = 2.609; 95% CI = 1.726-3.945) showed a positive regression correlation; therefore, individuals with low self-efficacy have 2.607 times more likely to engage in risky behavior. Hence, gender and self-efficacy variables were observed to influence the level of social distancing obedience by using multivariate logistic regression analysis, with the effect explained in the table

Table 1. Distribution of Perception and Behavioral Variables based on Cut-off Point Results (Low-High, Risky-Non Risky)

Variable	Low/Risky		High/Non Risky	
	n	%	n	%
Susceptibility	228	55.9	180	44.1
Severity	104	25.5	304	74.5
Benefits	62	15.2	346	84.8
Barriers	381	93.4	27	6.6
Self-efficacy	242	59.3	166	40.7
Behavior	212	52	196	48

Table 2. Relationship of Independent Variables with Social Distancing Obedience by the People of DKI Jakarta Province

Variable	Category	Behavior						95% CI	p-value	OR
		Bad		Good		Total				
		n	%	n	%	n	%			
Age (years)	Worker age	50	23.6	37	18.9	87	21.3	0.822-2.139	0.246	1.326
	Student age	162	76.4	159	81.1	321	78.7			
Gender	Male	60	28.3	30	15.3	90	15.3	1.338- 3.567	0.002*	2.184
	Female	152	71.7	166	84.7	166	84.7			
Education	Low	95	44.8	102	52.0	197	48.3	0.507-1.105	0.114	0.748
	High	117	55,2	94	48,0	211	51,7			
Occupation	Non student	110	51.9	89	45.4	199	48.8	0.878- 1.914	0.191	1.297
	Student	102	48.1	107	54.6	209	51.2			
Perceived susceptibility	Low	123	58.0	105	53.6	228	55.9	0.810-1.772	0.366	1.198
	High	89	42.0	91	46.4	180	44.1			
Perceived severity	Low	58	27.4	46	23.5	104	25.5	0.785-1.921	0.368	1.228
	High	154	72.6	150	76.5	304	74.5			
Perceived benefit	Low	36	17.0	26	13.3	62	15.2	0.774-1.310	0.296	1.337
	High	176	83.0	170	86.7	346	84.8			
Perceived barriers	Low	202	95.3	179	91.3	381	93.4	0.856-4.298	0.108	1.918
	High	10	4.7	17	8.7	27	6.6			
Self-efficacy	Low	148	69.8	94	48.0	242	59.3	1.673-3.764	<0.001*	2.509
	High	64	30.2	102	52.0	166	40.7			

Notes: *Chi-square Test Analysis p-value<α (α = 0.05), CI = Confidence Interval, OR = Odds Ratio

Table 3. Multivariate Analysis Results of Sociodemographic and Perception Variables on Social Distancing Obedience by the People of DKI Jakarta Province

Independent Variable	β	p-value	AOR	95% CI	
				Lower	Upper
Gender (Male)	0.844	0.001	2.327	1.404	3.857
Self-efficacy (Low)	0.959	<0.001	2.609	1.726	3.945
Constant	-1.978	<0.001	0.138		

Notes: * p-value<0.05, CI = Confidence Interval, AOR = Adjusted Odds Ratio

and discussion above.

Discussion

This study was conducted to determine the relationship between sociodemographic characteristics, public perception, and obedience regarding social distancing. Primary data were collected through online questionnaires, which have a higher risk of bias than the direct (offline) method. Furthermore, these online questionnaires contained some sentences that were a little ambiguous. However, this problem was solved by providing additional information in the question description column on the Google Forms to enable respondents to interpret and answer the questions easily. Study with this online system also required facilities, such as the internet or wifi. Therefore, respondents who have these amenities could only access this tool, often persons with higher incomes or better education. This limitation affected the uneven distribution of sociodemographic variables, such as age, gender, education, and occupation. Also, the data of several respondents submitted twice were neither processed nor used.

The study results indicated that the proportion of public obedience to health behaviors was at an undesirable level. Gender was observed as one of the demographic factors related to health behavior so that women showed healthier behavior than men since they had greater motivation for health.[19] Generally, women placed a higher emphasis on actual health, while men were focused on preventing diseases.[20] The male gender variable indicated a regression coefficient of 0.844 and OR = 2.327, where a positive value signifies that men are 2.327 times more likely than females. Also, people with higher education and older age had healthier behavior. This result was similar to Afrianti and Rahmiati's study which stated that age and education had a significant relationship with the implementation of health protocols during the COVID-19 pandemic; an individual's ability to engage in protective behavior increases with their level of education and age.[19] The results of this study were also similar to Riyadi and Larasaty's study in 2020 which stated that gender and age were related to health protocols behavior.[21] Young female respondents had higher compliance in implementing health protocols. Other factors in this study that influenced respondents' reaction status were perceived effectiveness of self-isolation, education level, health status, marital status, level of concern about pandemic news, and concern for mobility outside the house.[21]

The HBM theory was used to explain and predict health behavior. In 1974, Kirscht and Becker further developed this concept to investigate individual responses to symptoms and diagnosed disease, particularly adherence to medical advice.[17] The HBM theory developed by Becker focuses on four factors that influence an individual's health behavior: perceived susceptibility, seriousness, benefits, and barriers.[22] The independent variables of the HBM construct, which included perceived susceptibility, severity, benefits, barriers, and self-efficacy, were used to observe the respondents' health behavior, especially concerning social distancing policies. The previous study showed that the HBM affects an individual's level of obedience in executing health behavior policy.[2] Self-efficacy had a significance of less than 0.05 on the HBM construct perception variable.

Consequently, a statistically significant relationship exists between self-efficacy and obedience behavior in implementing social distancing if the logistic regression results have a significance of less than 0.05. This study found that low self-efficacy was associated with risky behavior. Self-efficacy is defined as the level of trust and confidence in overcoming barriers to healthy behavior.[18] According to the health belief model, individuals should have an appropriate level of self-efficacy to overcome barriers to behavior. This result was similar to Shahnazi *et al*.,[23] in their study in Iran, which concluded that high perceived self-efficacy is an essential factor in increasing the individual's obedience to adopting preventive behaviors from COVID-19.

The social distancing behavior frequency over the past month was under the DKI Jakarta Governor Regulation No. 3 of 2021 requires the public to maintain a safe distance in public places and transportation, including offices/workplaces, academic units (schools/campuses), worship centers, restaurants/cafes, markets/street vendors, and other crowded environments (wedding reception venue).[16] According to the HBM theory, an individual's health behavior is determined by their beliefs or perceptions of the illness and its prevention to reduce the disease incidence. This construct's perceptions consist of perceived susceptibility, severity, benefits, barriers, and self-efficacy.[22] Furthermore, an individual's perception can be influenced by modifying factors, cues to action, and information media.[24]

The results showed that most of the 212 (52%) respondents had risky behavior above the cut-off point. Therefore, many people disobeyed social distancing policies by engaging in inconsistent behaviors with these laws. This social distancing behavior could be divided into obedience in public places and transportation. However, the majority of respondents (19%) still left the house for work and use public transportation, such as online/base motorcycle taxis (8%), with worship centers (69%) and urban transportation/microbuses (87%) having the highest number of participants. The multivariate results illustrated that factors, such as gender (OR = 2.327; 95% CI = 1.404-3.857) and self-efficacy (OR = 2.609; 95% CI = 1.726-3.945 influenced social distancing behavior. This study showed that people in DKI Jakarta Province currently tend not to comply with the implementation of social distancing policies. This happened because they were still ignoring the government's recommendations or were saturated with complying with regulations due to the length of the COVID-19 pandemic. In order to make people obey, the government must be consistent in providing socialization and education related to the spread of COVID-19. The government must also be more vigorous in action against policy violators so that the community can comply with social distancing policies during the pandemic. The government and the community are expected to take the initiative and maintain their health by implementing health protocols and complying with policies that the government has implemented.

The limitation of this study was that there were a few ambiguous sentences in the questionnaire. However, the authors provided additional descriptions on the Google Form, so the respondents did not misperceive the questions. Using the online questionnaire could also limit groups' ability to respond to an online questionnaire without internet access. So, the questionnaire could only be accessed by respondents with internet access or all the facilities needed and might only represent respondents with higher income or better education. This limitation affected the unequal distribution of sociodemographic variables, including age, gender, education, and occupation. Further studies should be conducted to facilitate a comprehensive overview of people's perception and obedience in implementing social distancing policies so that the government can monitor and evaluate their policies.

Conclusion

Based on the results of this study, a sociodemographic characteristic that affects people's obedience is gender. Gender had a significant relationship with obedience in implementing social distancing policy, where the males tend to have more risky behavior and disobey the social distancing policies. Logistic regression test showed self-efficacy had a statistically significant correlation with social distancing and had the highest odds ratio. Individual obedience to social distancing policies increased their level of perceived self-efficacy.

Recommendation

The Indonesia Government should improve coordination between the central and local governments and other parties (people/regional leaders) in providing regu-

lated socialization and education. This recommendation aims to provide people with policy certainty to encourage public participation in social distancing and pay serious attention to improving public awareness or obedience social distancing policies, especially for males. The Government should consider the risky behavior and unsatisfactory obedience in social distancing policies by providing relevant information to influence public perceptions and encouraging people to engage in preventive behaviors. Enhancing discipline by sanctioning individual and institutional policy violators is also the issue to be raise. Furthermore, through information technology, the people should be more proactive in seeking information on COVID-19 and government policies, including the objectives and benefits of social distancing. Also, obedience to implementing these guidelines during the pandemic should be increased. Scientists and health professionals should (1) Develop and conduct further research on the relationship between independent variables and the social distancing behavior and; (2) Improve health promotion and provide the people with regular information on the benefits of social distancing.

Abbreviations

DKI: *Daerah Khusus Ibukota*; COVID-19: coronavirus disease 2019; WHO: World Health Organization; UK: the United Kingdom; USA: the United State of America; SEIQR: Susceptible-Exposed-Infectious-Quarantine-Recovered; LSSR: Large-Scale Social Restrictions; PSBB: *Pembatasan Sosial Berskala Besar*; HBM: Health Belief Model; SARS: Severe Acute Respiratory Syndrome; CI: Confidence Interval.

Ethics Approval and Consent to Participate

The Commission has approved this study for Research Ethics and Public Health Service, Faculty of Public Health, University of Indonesia Number: Ket-436/UN2.F10.D11/PPM.00.02/2021.

Competing Interest

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

Availability of Data and Materials

The datasets used and or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' Contribution

DS made the concept and design of the proposal and looked for the grant for this study. W and EBS were involved in the design study, performed data collection, analyzed data, compiled and revised the paper. BW, AK and RM analyzed data and involved in the discussion. All authors read and approved the final manuscript.

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