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Preface

Healthscope (e-ISSN: 2735-0649) is a peer-reviewed and evidence-based scientific research book published by Faculty of Health Sciences, Universiti Teknologi MARA, Puncak Alam Campus, Malaysia. The research book's mission is to promote excellence in health sciences and a range of disciplines and specialties of allied health professions. It welcomes submissions from academic and health professionals' community. The research book publishes evidence-based articles with solid and sound methodology, clinical application, description of best clinical practices, and discussion of relevant professional issues or perspectives. Articles can be submitted in the form of research articles, reviews, case reports, and letters to the editor or short communications. The research book's priorities are papers in the fields of Physiotherapy, Occupational Therapy, Optometry, Medical Laboratory Technology, Environmental Health & Safety, Nursing, Nutrition & Dietetics, Medical Imaging and Basic Sciences. Relevant articles from other disciplines of allied health professions may be considered for publication.

Dr. Siti Nor Ismalina Isa
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REVIEW ARTICLE

Prevalence and factors of overweight and obese among adolescent in Asia: A scoping review

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Abstract:

This study aimed to estimate the prevalence or trends of overweight and obesity among adolescents in Asia countries and identify the associated risk factors between 2012 to 2020. The study design for this scoping review was carried out using SCOPUS, Web of Science and Google Scholar Databases for relevant studies in Asia countries. The inclusion criteria were Asian adolescents with ages ranging from 10 to 19 years old and geographical location. All studies on the prevalence and risk factors of overweight and obesity among adolescents in Asia countries were performed from September 2012 to the end of November 2020. Quality assessment and data extraction were based on The Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Cross-sectional studies. Overweight and obesity were higher among boys than girls although some reviews did not discuss which sex had a higher proportion of prevalence. In addition, there was some evidence about potential contributors to childhood overweight and obesity in Asia countries. Due to differences in survey sampling methods, sample size and age range of subjects, the prevalence and the risk factor of overweight and obesity required careful interpretation.

Keywords: Adolescents, Asia, Risk factor, Obesity, Overweight

1. INTRODUCTION

Obesity and overweight are defined as abnormal or excessive fat accumulations that might be detrimental to one's health. According to the World Health Organization (WHO), the worldwide incidence of obesity almost quadrupled between 1975 and 2016. Concerns about utilising BMI for adults apply to adolescents as well. In addition to age, weight, and pubertal development, height and degree of sexual maturity have an impact on the association between BMI and body fat among adolescents. Obesity has been linked to a variety of risk factors, including genetics, lifestyle, specific illnesses, and drug use. Lifestyle factors, relatively higher consumption and limited physical exercise have been recognised as important contributors leading to obesity, especially in adolescents (Ahmad *et al.,* 2018). In addition, Various indicators with varied limits and strengths have been used to estimate overweight and obesity. Therefore, across all age categories, only the body mass index (BMI) is the most acceptable technique for assessing weight status (Motlagh *et al.,* 2018; Pawaskar *et al*., 2015). Body Mass Index (BMI) was estimated by dividing weight(kg) by height(m) squared (Hernández-Cordero *et al.,* 2017). However, there is very minimal research on the prevalence among adolescent settings in Asia.

Although the world's lowest rates of overweight and obesity are found in Southeast Asia, the growth rate has been significant during the last 10 to 15 years. Other than that, obesity in adolescents has been linked to the development of serious health issues such as type 2 diabetes, high blood pressure, asthma and other respiratory disorders, sleep disorders, and liver disease (WHO, 2014). In the global trend, the prevalence of childhood overweight and obesity grew by 10% (Elías-Boneta *et al.,* 2015; De Onis M *et al.,* 2010). Childhood obesity in the United States has more than doubled in the previous 30 years, and it has quadrupled among adolescents (Elías-Boneta *et al.,* 2015; Ogden CL *et al.,* 2014). In addition, the overall prevalence of obesity among adolescents at age 11 to 14 years old has been found (Dundar *et al.,* 2012; Archenti *et al.,* 2008). Based on surveys of children in the mainland United States and Puerto Rico, obesity rates among Puerto Rican adolescents in the U.S. and Puerto Rico are among the highest which result in 24-36% (Elías-Boneta *et al.,* 2015; Acosta-Pérez *et al.,* 2012). While other countries such as Mexico also point out that overweight and obesity have grown at the greatest rate among female adolescents during the previous 13 to 24 years. In all age categories except preschool children and those from urban regions, the growth in overweight and obesity has been more evident among children from the lowest socioeconomic level. Furthermore, overweight and obesity are highest in Mexican children even though compared in prevalence with other countries by using WHO classification

systems (Hernández-Cordero *et al.,* 2017). While in the Asia region, it shows that the prevalence of overweight and obesity is increasing day by day regardless of population areas. For example, the prevalence of overweight and obesity in China has shown significant increases among adolescents between 2011 and 2015. Given the high probability of BMI tracking from adolescence to adulthood, the rise and increased frequency of obesity in adolescents is worrying (Zhang *et al.,* 2018; Simmonds *et al.,* 2016).

Considering these, the main objective of this study was to review the percentage of prevalence of overweight and obesity and identify the associated risk factor which causes overweight and obesity among adolescents in Asia.

2. MATERIALS AND METHODS

This scoping review was reported according to the Preferred Reporting Items for scoping reviews and Meta-Analyses (PRISMA) Statement (Page *et al.,* 2021). A scoping review design was conducted to identify, assess, and summarize the available evidence on the prevalence of overweight and obesity with associated risk factors that causes overweight and obesity among adolescents in Asia. A combination of text words and MeSH terms and a Boolean search were used to search Web of Science, SCOPUS, and Google Scholar as the main worldwide electronic data sources to evaluate studies on obesity or overweight with associated risk factors in adolescents in Asia. In addition, websites of relevant agencies such as the International Obesity Task Force (IOTF), the Centre for Disease Control and Prevention (CDC), and the World Health Organization (WHO) were browsed. The data was managed by using the Endnote version 20 reference management system. However, a manual search for other articles and references to published articles were included. For inclusion criteria, the population comprised adolescents aged 10 to 19 years old in Asia countries such as India, Bangladesh, Pakistan, Nepal, Afghanistan, China, Malaysia, Thailand, Vietnam, Japan, Arab Saudi, Turkey, Indonesia, and Sri Lanka while for exclusion criteria, the papers of non-countries-based studies and duplicate citations were excluded.

The first researchers reviewed 536 titles. A total of 499 full-text papers were obtained and assessed against a set of inclusion criteria. Only 422 were eliminated based on the title and abstract. A total of 77 articles were sought for retrieval and only 23 articles were not retrieved. Meanwhile, 26 full-text articles were excluded due to issues relating to the mixed prevalence of overweight and obesity, not based on age range and review articles. Only 54 articles were assessed for eligibility and 28 articles were included in the review. The selection process was illustrated in Figure 1. The full-text articles were assessed by at least two reviewers. Data extracted included date of publication, study design and setting, age and sex, statistical method, prevalence, and risk factors associated with overweight and obesity. The Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Cross-sectional studies was applied and used to determine the potential risk of bias.

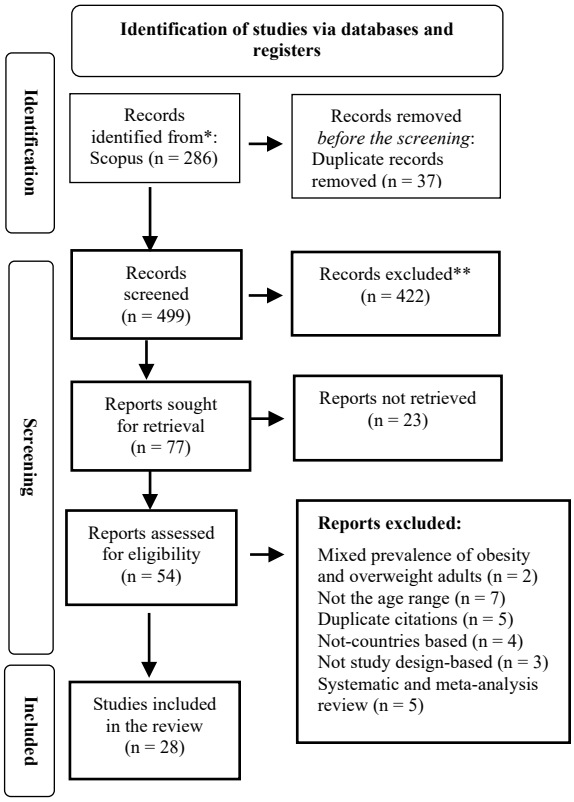

Figure 1 PRISMA Flow chart for the studies selection

3. RESULTS

3.1. Literature search

The search on the prevalence of overweight and obesity with a risk factor that can cause overweight and obesity among adolescents returned a total of 54 articles. By using JBI Critical Appraisal Checklist for Cross-Sectional Studies, 28 articles were reviewed for full-text articles according to inclusion criteria and 23 articles were eligible for general review. The majority of the studies were done in Arab countries(eight) followed by ASEAN countries(seven), followed by India(four), China(two) and Japan(one). The population consisted of adolescents from around age 10 until 19 years. Seven of the studies observed the prevalence of overweight and obesity based on age, sex, and country. The subjects were classified by sex female and male while the age ranges from 14-16, 12-15, 11-14, 14-19 and 11-18, respectively.

3.2. Prevalence of overweight and/ or obesity

The prevalence of overweight and/ or obesity from 18 countries were included in this study based on the classification method. About eight studies were using WHO guidelines while the other five studies were using IOTF guidelines and others combine with NHNS, CDC, and

NCHS guidelines. Based on the data given by using WHO guidelines, the highest overweight rate was in Ho Chi Minh, Vietnam at 19.6% and the lowest prevalence of overweight was in Chennai, India with 6.2% respectively. Meanwhile, obesity rates in Riyadh City, Saudi Arabia and Hanoi, Vietnam was higher (20.2% and 19.1% respectively) than in Changchun City, China with the lowest obesity rate among girls (3.1%).

Nguyen *et al.* conducted multistage cluster sampling and stated the prevalence of overweight and obesity by using three criteria; WHO shows 19.6% and 7.9%, IOTF shows 17.8% and 3.2% while CDC shows 14.1% and 3.2%, respectively. In addition, Phan *et al.* also conducted cluster sampling by using IOTF and WHO guidelines. The prevalence of overweight and obesity by using WHO and IOTF (17.4% and 17.1% respectively) and (8.6% and 5.4% respectively). While Pengpid *et al*. had taken a different approach by focusing on ASEAN countries. The prevalence of obesity was highest in Brunei and Malaysia (17.7% and 9.6% respectively) and the lowest was in Cambodia, Myanmar, and Vietnam (0.4%, 0.4% and 0.6% respectively). Meanwhile, the prevalence of overweight or obesity was also highest in Brunei (36.1%) and Malaysia (23.7%) and the lowest of overweight or obesity was in Cambodia (3.7%) and Myanmar (3.4%).

3.3. Risk factors associated with overweight and obesity

15 studies examined the association between lifestyle with overweight and obesity in adolescents. Only seven studies reported a significant association in lifestyles that involved risk factors overweight, and obesity. Four studies found that most adolescents were overweight or obese because of too spent over 2 hours or 4 hours of screen time per day. Other studies also showed a positive association between low physical activity with overweight or obesity.

The association between nutritional intake with overweight and obesity was assessed in ten studies. Most of the studies showed that a high intake of fast food, carbonated drinks and less consuming fruits and vegetables may be associated with overweight or obesity among them. In addition, two studies showed that irregular or skipped breakfast habits can also risk overweighting and obesity (Dundar *et al.,* 2012 and Al-Haifi *et al.,* 2013). All six studies also examined the association between consuming fruits or vegetables occasionally, increased consumption of energy-dense food intake, and having more fast food were positively related to the risk of overweight or obesity.

Nine studies examined the association between genetics, gender and environment with overweight and obesity. About five studies were positive and showed that male adolescents were high risk of overweight or obese than female adolescents. Other same studies also related parental BMI to overweight and obesity among adolescents. In addition, one study showed different results with overweight, or obesity can be related to not walking or biking among adolescents (Pengpid *et al.,* 2016). Meanwhile, six studies showed that families with high or middle socioeconomic status were at high risk of having overweight or obesity. One study that was conducted showed that adolescent girls from high-income families tend to get overweight or obese compared to adolescent boys (Noh *et al.,* 2014). Furthermore, other studies associated overweight or obesity with adolescents living in urban areas and who go to private schools tend to get overweight or obese more than in public schools (Dundar *et al.,* 2012).

4. DISCUSSION

This study aimed to review the prevalence of overweight and obesity among adolescents and the risk factors that were associated which causes overweight and/ or obesity among adolescents in Asia. It's worth mentioning that twenty-three of the twenty-eight studies carried out were of high-quality articles. In addition, according to the JBI Critical Appraisal Checklist for Cross-sectional Studies, four studies were considered to have a moderate risk of bias, while one study was classified as a high risk of bias. These studies could have lacked appropriate statistical methodology or design and were unclear of exposure measures and confounding variables. Both prevalence and risk factors that were associated with overweight and obesity among adolescents in Asia included in the studies range widely. As mentioned in the literature review, adolescents' obesity or being overweight had been increasing and may have serious health consequences that last into adulthood (Pengpid *et al.,* 2016; Reilly and Kelly *et al.,* 2011).

Regarding the previous article, when prevalence was analysed according to sex, about half of the countries that showed the prevalence of overweight, or obesity were higher among boys than girls. The other half only indicated that both boys and girls were higher in the prevalence of obesity and overweight. These results were reliable with the previous studies that stated a high prevalence of abdominal obesity among boys (Elías-Boneta *et al.,* 2015). Gender differences in the prevalence of overweight or obesity had been linked with lifestyle variables (Al-Hazzaa *et al.,* 2012; Duncan *et al.,* 2011 and Lazarou *et al.,* 2010). Ten articles compared data based on classification methods and pointed out that the World Health Organization (WHO) showed a higher prevalence of overweight and/ or obesity among adolescents in both sexes over this period.

Using the World Health Organization (WHO), about six articles based in Vietnam, India, Iran, China, and Malaysia countries showed that the prevalence of being overweight was higher among both sexes. Based on the region in that countries, Ho Chi Minh, Vietnam (19.6%), Kuala Terengganu and Besut, Malaysia (15.6%), and Tehran, Iran (14.4%) showed that higher prevalence of overweight than Nepal (12.2%) and Chennai, India (5.2%). Furthermore, three articles based on Vietnam, Saudi Arabia and China countries showed a higher prevalence of obesity among adolescents. The review also stated that the regions from

Hanoi, Vietnam and Riyadh City, Saudi Arabia showed (19.1%) and (20.2%) higher obesity prevalence (Pham et *al.,* 2019 and Al-Husaini *et al.,* 2019). Meanwhile, in Kajang, Malaysia showed a higher prevalence of both overweight and obesity among both sexes with only (19.5%) (Rezali *et al.,* 2012).

By using the International Obesity Task Force (IOTF) guidelines, 41.7% of urban boys in the Gujarat, India area were overweight and obese. This study confirms that the male gender and high socioeconomic status were associated with a significant risk of being both overweight and obese (Alok *et al.,* 2012). In comparison with the urban school in South India, 11% of boys were overweight and 5% of girls were obese. The most interesting finding was no difference between boys and girls for the prevalence of both overweight and obesity. Another important finding was based on Kuwaiti (50.5%) and Saudi Arabia cities (46.3%) were higher in both overweight and obesity for boys than girls in Kuwaiti (46.5%) and Saudi Arabia cities (34.8%).

In ASEAN countries, the prevalence of both overweight and obesity among adolescents increased in Brunei (36.1%) and Malaysia (23.7%) for both sexes. However, the other two countries showed the lowest prevalence of overweight and obesity among adolescents in Myanmar (3.4%) and Cambodia (3.7%) based on analyses in Global School-based Student Health Survey (GSHS) guidelines. Overall, there are no substantial differences between boys and girls. This could be due to a difference in puberty transition, with boys being more vulnerable to obesity than girls, as has been found in lower middle and upper middle-income nations (Pengpid *et al.,* 2016 and Poskitt *et al.,* 2014). Analyses of trends in overweight and obesity prevalence for the two National Centre for Health Statistics (NCHS) and Centre for Disease Control and Prevention (CDC) guidelines indicated that the higher prevalence of overweight (27.9%) and obesity (10.9%) among boys than girls at Samsun, Turkey (Dundar *et al.,* 2012). In Changchun City, China was in line with those of previous studies with the prevalence of overweight (17.4%) and obesity (8.8%) higher among boys than among girls. Meanwhile, the Islamic Republic of Iran only indicated the prevalence of overweight and obesity for both sexes (Motlagh *et al.*, 2018).

Although the prevalence of overweight and obesity is measured differently in different studies around the world, it was on the rise in most of them as a common factor. In the Global Burden of Disease Study's analyses, the global prevalence of overweight and obesity in children and adolescents was also estimated. Based in the previous year in 2013 reported that the prevalence of obesity among children and adolescents in developed countries was high which is approximately 24% of boys and 23% of girls were overweight or obese. In general, since 1980, the rate of overweight and obesity had steadily risen (Seidell *et al.,* 2015 and Ng *et al.,* 2013). There were significant differences in the prevalence of obesity or overweight in different parts of Asia, which could be due to cultural differences and socioeconomic reasons in different provinces. As a result of globalisation and rising urbanisation, many Asia countries were undergoing socioeconomic and lifestyle changes. In Singapore, Korea, Malaysia, Philippines, and Indonesia, more than 60% of the population lives in cities, compared to less than 30% that lives in China, Pakistan, India, and Thailand. Meanwhile, Bangladesh and Sri Lanka had poor urbanisation rates (Ramachandran *et al.,* 2012).

The studies showed that the lack of physical activity was the one key factor that was associated with overweight or obesity among adolescents. According to studies, children and adolescent populations in most regions were low levels of general physical activity, high levels of sedentary behaviour, and an increasing prevalence of obesity (Zhu *et al.,* 2019). Around 80% of adolescents (ages 13–15) worldwide do not fulfil recommended criteria, indicating they do not spend more than 60 minutes per day engaging in moderate-vigorous physical activity (MVPA), including vigorous activities on at least three days per week (Zhu *et al.,* 2019 and Hallal *et al.,* 2012). In many countries in the region, technological developments, and gadgets such as computers, online games and various widely available television channels seem to be resulting in long periods of inactivity at home for most adolescents. The most obvious finding to emerge from the results indicated that less frequently engaged in vigorous physical activity and long watching television for more than two hours per day were reported as a risk factors of childhood overweight and obesity. Long-term television viewing may lead to a desire for high-fat, high-sugar, and high-calorie snacks, resulting in increased energy intake from eating while watching and/or the effects of advertising, as well as a reduction in sleep. This finding supports evidence from laboratory-based experiments (Robinson *et al.,* 2017) that exposure to screen media resulted in increased energy consumption without increased appetite or compensatory decreased intake during the rest of the day.

Adolescents became more independent during this time and had more food options outside of those accessible at home (Al-Hazza *et al.,* 2021). These findings indicated that there was a global link between dietary intake and overweight and obesity, despite disparities in cultural and economic settings among Asia countries studied. Based on nine cross-sectional studies, the results indicated that high consumption of fast-food, sugar beverages, energy dense food, lower frequencies of vegetables and fruit intake and skipped breakfast tend to increase the risk of overweight and obesity among adolescents. Meanwhile, one unexpected finding confirmed that most students who consumed breakfast daily had the lowest prevalence of overweight and obesity. In addition, skipping breakfast was linked to changes in appetite and satiety, which can lead to overeating and poor insulin sensitivity (Robinson *et al.,* 2017). Other results also found that there was no statistically significant

link between fast food consumption and obesity. However, the portion size of fast foods, which was not considered in this study, could be a misleading factor in the relationship between fast food consumption and obesity (Al-Hazza *et al.,* 2012).

According to international data, obesity was more common in boys than girls around 5–19 years old in higher middle-income countries in the world (Shah *et al.,* 2020). The results of all studies indicated that male adolescents were higher in overweight and obesity than female adolescents. These results seem to be consistent with other research which found some studies that girls, particularly those in higher-income areas, choose diets that were low in energy and high in nutrients, such as fruits and vegetables, while boys consume more meat and calorie-dense foods. Moreover, in comparison to males, girls were more likely to have weight-related issues, such as a desire to lose weight, guilt over overeating, and low self-esteem (Shah *et al.,* 2020 and Wang *et al.,* 2018). As shown by other studies, family history of overweight and obesity among parents also tend to be associated with childhood obesity. By hereditary features or family living styles, the overweight or underweight status of parents may influence the overweight in children or adolescents (Noh *et al.,* 2014). However, because the overweight of parents was measured by adolescents, there was a chance that this measurement was biased. As a result, effective treatments to prevent the inheritance of obesity were required (Noh *et al.,* 2014).

Socioeconomic status (SES) was initially expected to be a significant risk factor for childhood obesity. Other well-known determinants of childhood overweight, such as parental weight status and physical inactivity were known to be influenced by socioeconomic status (SES) (Gätjens *et al.,* 2020). The finding indicated that adolescents with middle and higher SES were at risk of becoming overweight and obese. Following the present results, previous studies had demonstrated that there was a link between being overweight or obese and having a high income such as total family or daily pocket (Okour *et al.,* 2019). Children from higher-income status had a greater selection of eating options, including restaurant meals that were often higher in calories, fat, and salt.

5. LIMITATION

This study had several potentials limitations. Several populations had different ideal cut-off points in assessing overweight and obesity, hence overweight and obesity may be defined differently based on anthropometric measures in different countries. Due to differences in survey sampling methods, sample size, the age range of subjects, the prevalence and the risk factor of overweight and obesity required careful interpretation. Individual studies were also limited to selected locations, with participants consisting of adolescents attending schools, it was limiting the ability to produce a view that was representative of the different countries.

6. CONCLUSION

The findings of this study, the following conclusions may be drawn such as the prevalence of overweight and obesity among adolescents in Asia countries is still high but not consistently. Overweight and obesity higher among boys than girls although some reviews did not clearly mention which sex had a higher proportion of prevalence. With urbanisation, physical activity decreases, and the way people eat was changing dramatically, especially among adolescents. People in cities had easy access to a variety of diets that were high in refined carbohydrates, processed foods, saturated and total fat, and low in fibre (Ramachandran *et al.,* 2012). There was some evidence about potential contributors to childhood overweight and obesity in these countries, as discussed in the review, but a detailed knowledge of the associated cultural, social, and environmental factors, including dietary and behavioural factors, was required. In addition, there were some criteria to be used to classify adolescents as overweight or obese, such as World Health Organization (WHO), International Obesity Task Force (IOTF), Centre for Disease Control and Prevention (CDC), Japan National Health and Nutrition Survey (NHNS) and Global School-based Student Health Survey (GSHS) but most often used was the WHO and IOTF references.

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RESEARCH ARTICLE

Determining knowledge, attitudes, and practices on food waste management among Health Sciences students in Universiti Teknologi MARA

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Abstract:

This study aims to determine food waste management among students in Universiti Teknologi MaraUiTM). The information was collected by using a questionnaire comprising four sections: demographic information, knowledge, attitude and practice on food waste. The number of respondents involved was 201. The finding showed that the students have a high level of knowledge (3.935 ± 0.9699), attitude (5.100 ± 0.9798) and practice (2.672 ± 0.8897) towards food waste management. There was a positive significant correlation between knowledge with attitude (rs = 0.217, p = 0.02), and attitude with practice (rs = 0.241, p = 0.01). However, the correlation of knowledge with practice (rs = 0.073, p = 0.31) was not statistically correlated. There was a significant association between knowledge with gender (rs = 14.800, p = 0.011), and attitude with gender (rs = 15.449, p = 0.009) meanwhile there was no significant association between practice and gender (rs = 8.900, p = 0.064). Furthermore, there was no significant association between knowledge with income (rs = 15.025, p = 0.131), attitude with income (rs = 9.381, p = 0.496), and practice with income (rs, 9.054, p = 0.338). Hence, the results suggest that to change people's behaviour in waste management, the knowledge and awareness in waste management must be improved sustainably so that it will change a person's attitude and form it into positive action.

Keywords: Attitudes, knowledge, practices, food waste, institutional

1. INTRODUCTION

In the past decade, food waste has received increased attention on both academic and societal levels. Generally, food waste sources can be classified into three groups: food losses, unavoidable food waste, and avoidable food waste (Thi et al., 2015). According to Elimelech et al., (2018), household food waste accounted for 45% of total waste, or 573g per capita, of which 54% was identified as preventable. According to United Nations Food and Agriculture Organization (UNFAO), food waste is referred to the decrease in the quantity or quality of food resulting from the decisions and actions by retailers, food service providers, and consumers. The authority is up against formidable obstacles in the management and disposal of food waste. Food waste contributes to the current environmental problem because it is improperly separated from urban solid waste, resulting in the generation of greenhouse gases in landfills. Food waste disposal is classified under the disposal of solid waste, which may include any method from destruction, incineration, deposit or decomposing under the Malaysia Solid Waste and Public Cleansing Management Act 2007 (Act 672).

As a cause of adverse economic, environmental, and social effects, food waste is considered to be one of the sustainability issues that need to be addressed (Aschemann et al., 2015). Food waste may have negative environmental impacts at the end of its life depending on how it is managed such as in landfills, the food waste converts to methane, which is a greenhouse gas with a global warming potential twenty-five times greater than carbon dioxide on a hundred-year time scale. Food waste is not only associated with ethical concerns and environmental consequences; it also represents significant monetary losses, both for the individual consumer and the national economy (Ponis et al., 2017).

Consumers are one of the largest sources of preventable food waste in developed countries, with over 60% of their waste considered avoidable (Nikolaus et al., 2018). (Bravi et al.,2020) stated that several studies, mainly focused in North America, highlighted the large amount of food waste

generated by institutions, such as schools, universities, hospitals and hotels. Large population of students in a university will result in increased consumption of food and the resources required to make the food such as water and energy. According to (Abdelaal et al.,2019) by focusing research efforts on food waste generation in universities, many advantages can be gained because universities host individuals with knowledge and experience who can easily foster change in their surroundings.

According to (Wu et al.,2019) low students' awareness of the adverse environmental problems related to food waste may derive from insufficient information provision. Chalak A, Abou-Daher C, Abiad MG (2018) stated that improper food waste practices include purchasing too much food, using unsuitable storage practices, cooking too much food, and discarding leftovers. There are several reasons involving the knowledge, attitude and approach (KAP) of a person which lead to the generation of food waste in the household include lack of food-related knowledge, personal values, and poor cooking skills (Bech-Larsen T, Tsalis G, 2018). These reasons may be associated with socio-demographic characteristics of an individual such as age, gender and family household income. Conventional models for predicting solid waste generation are based on socio-economic and demographic factors (Bach et al., 2004), these include the age, household income, gender and educational level.

This study aims to determine the food waste management among students in Universiti Teknologi Mara. This study can provide the university with baseline information on students' overall knowledge, attitude, and practice (KAP) on food waste management. Proper food waste management can be established by determining the association between students' socio-demographic and KAP on food waste. Insights from this study can inform future interventions that focus on reducing the amount of avoidable wasted food among the younger generation such as university students, as the impacts are realizable.

2. MATERIALS AND METHODS

2.1. Study design

This was a cross-sectional study conducted among undergrad students. The target respondents of the study were students (19 to 25 years old) who are currently pursuing Bachelor's degree programs in full-time mode. The online questionnaire was distributed through social media (i.e: Whatsapp and Facebook platforms). Participation by respondents was voluntary and sufficient time (10-15 min) was allowed to answer the questions.

2.2. Questionnaire

The questions were generated in the Google form which divides into four parts consisting of socio-demographic information (5 questions), knowledge on food waste management (5 questions), attitude in food waste management (6 questions), and practices on food waste management (4 questions). The respondents answered the questionnaire which comprises of twenty questions after clicking the form's link. A Likert scale was used in constructing the questions for the knowledge, attitude, and practice of students on food waste management. Each of these questions have a set number of response the respondent can choose from, respectively strongly agree, agree, neutral, disagree and strongly disagree. Respondents describe their agreements using a five-point scale, ranging from "1 equal to strongly disagree" to "5 equal to strongly agree". Meanwhile, the demographic questions were in dichotomous and nominal scales.

2.3. Pilot study

A pilot analysis was conducted on 30 household, which were not included in the actual experiment (Al-Kandari et al., 2019). The questionnaire was reviewed and updated as a pilot to be consistent with the community. Based on the reliability test conducted for 30 persons, the result for the Cronbach's Alpha as shown in Table 1 was 0.809. Hence, the questionnaire was reliable because the value for Cronbach's Alpha was more than 0.7. Then, the questionnaire was distributed to the target sample.

2.4. Data Analysis

Data entry and statistical analysis were performed using the Statistical Package for Social Sciences (SPSS) version 22.0 (SPSS, Inc., Chicago, IL, USA). All the categorical variables will be presented as frequencies and percentages. Spearman correlation test was used to determine the potential correlation between KAP. Pearson chi-square test was used to confirm the possible association between sociodemographic characteristics and KAP.3.

3. RESULTS AND DISCUSSION

3.1. Socio-demographic information of the respondents

The socio-demographic characteristics for two hundred and one (n = 201) students are presented in Table 1. Majority of the respondents were females (89.05%), with a minority of male respondents (10.95%). The study only targeted respondents whom from the age 19 years old to 25 years old and currently studying in full-time mode. Regarding the respondents' participation in terms of their field of study, most of the participants were from Medical Imaging (27.86%), followed by Environmental Safety and Health respondents (21.39%). Most of the respondents came from a household family with an income below RM 4,360 (49.25%). 35.82% of the respondents were from households with an income range between RM 4,360 to RM 9,619, least of the respondents (14.93%) came from family households with

income above RM 9,619.

Table 1. The socio-demographic data of the respondents (n = 201).

Socio-Demographic Characteristics	Category	Percent (%)
Age	Below 19 years old	-
	19 – 25 years old	100
	25 years old and above	-
Gender	Male	10.95
	Female	89.05
Income of Family Household	Below RM 4,360	49.25
	RM 4,360 – RM 9,619	35.82
	RM 9,619 and above	14.93

The total score of KAP for each question was calculated and recorded. Overall, the respondents show high level of knowledge, attitude and practice on food waste management. The knowledge section was made up of 5 questions, with '1' score given for each correct answer and zero score for the incorrect answer. From the result shown in Table 2, 119 respondents (59.2%) know that there is an enforcement of law on waste segregation in certain states such as Kuala Lumpur, Putrajaya, Pahang Johor, Melaka, Negeri Sembilan, Perlis, and Kedah in Malaysia. According to Table 3, most of the respondents (94.5%) know that having a knowledge on proper food waste management can help reduce daily food wastage. Besides, 155 (77.1%) of the respondents had an idea that the "Use by" date indicates when a product may no longer be safe to eat. Meanwhile, a total of 144 respondents (71.6%) know that the "Best before" date is an indication of quality rather than safety. Ninety-three percent of the respondents know that improper food waste management can contaminate the environment.

Table 2. Respondents' knowledge on food waste management.

Knowledge	Frequency	Percent (%)
There is an enforcement of law on waste segregation in certain states (Kuala Lumpur, Putrajaya, Pahang, Johor, Melaka, Negeri Sembilan, Perlis, and Kedah) in Malaysia.	**119**	**59.2**
Knowledge on proper food waste management help in reducing daily food wastage.	**190**	**94.5**
"Use by" date indicates when a product may no longer be safe to eat.	**155**	**77.1**
"Best before" date is an indication of quality rather than safety.	**144**	**71.6**
Improper food waste management contaminates environment.	**187**	**93.0**

The attitude section was made up of 6 questions, with '1' score given for each correct answer and zero score for the incorrect answer. Based on the result from Table 3, most respondents (72.6%) have agreed that waste generators are responsible for food waste management. A total of 137 respondents (68.2%) were aware of how much food they wasted every day. In addition, most of the respondents (91.0%) had a favorable attitude that food waste can negatively impact the environment. Ninety-eight percent of the respondents agree that proper food waste management will provide better protection for the environment. Moreover, ninety-five percent of them decided that the frequency of shopping will reduce food waste generation by carrying out appropriate planning of purchasing. Last but not least, most of the respondents (86.1%) agreed that campaigning and public education programs can lead to successful food waste management.

Table 3. Respondents' attitude in food waste management.

Attitude	Frequency	Percent (%)
Waste generators are responsible for food waste management.	**146**	**72.6**
I am aware of how much food I wasted daily.	**137**	**68.2**
Food waste can negatively impact the environment.	**183**	**91.0**
Proper food waste management will provide better protection for environment.	**196**	**98.0**
Proper purchasing planning (listing down items to buy, frequency of shopping) will reduce food waste generation.	**191**	**95.0**
Campaigning and public education programmes can lead to a successful food waste management.	**173**	**86.1**

The practice section consisted of 4 questions, with '1' score given for each correct answer and a zero score for the incorrect answer. Based on Table 5, sixty percent of the respondents stated that they regularly plan their purchases by writing a shopping list. In addition, a total of 174 respondents (87.0%) periodically checks the "use by" and "best before" dates on the product before buying any item. Thirty-five percent of the respondents frequently buy food in bulk from promotional buying. Then, the majority of the respondents (80.0%) said that they only buy things when necessary.

Table 4. Respondents' practice in food waste management.

Practice	Frequency	Percent (%)
I regularly plan my purchase by writing a shopping list.	**132**	**66.0**
I regularly check the "use by" and "best before" dates on product before buying.	**174**	**87.0**
I frequently buy food in bulks from promotional buying.	**70**	**35.0**
I only buy things when necessary.	**160**	**80.0**

3.2. Correlation between knowledge, attitude, practice of students on food waste management

Based on Spearman's rank-order test, the correlation test between total knowledge, total attitude and total attitude score was done against total KAP scores. The result was shown in Table 5 where, a significant positive correlation was found between knowledge with attitude (rs = 0.217, p = 0.02) and attitude with practice (rs = 0.241, p = 0.01). However, the correlation between knowledge with practice was weak (rs = 0.073, p = 0.31).

Table 5.Correlation among knowledge, attitude and practice levels.

Level	Spearman's rho	Sig.
Knowledge – Attitude	**0.217**	**0.02**
Knowledge – Practice	**0.073**	**0.305**
Attitude – Practice	**0.241**	**0.001**

****Correlation is significant at the 0.01 level (2-tailed).**

3.3 Association of Socio-Demographic with Knowledge, Attitude and Practice

The relationship between demographic characteristics and knowledge, attitude, and practice was assessed by Pearson Chi-square test at a significance level of less than 0.05. A summary of association between knowledge, attitude, and practice level was shown in Table 6 and Table 7. From Table 6, there was a significant association between knowledge with gender (rs = 14.800, p = 0.011), and attitude with gender (rs = 15.449, p = 0.009). However, there was no significant association between practice and gender (rs = 8.900, p = 0.064). From result in Table 7, there was no significant association between knowledge with income (rs = 15.025, p = 0.131), attitude with income (rs = 9.381, p = 0.496), and practice with income (rs, 9.054, p = 0.338) as the the p-values for the Pearson chi-square test were more than 0.05.

Table 6. The association of respondents' gender and KAP.

	Gender	
	Chi-square test	
	Pearson chi-square	**Asymp. Sig**
Knowledge	**14.800**	**0.011**
Attitude	**15.449**	**0.009**
Practice	**8.900**	**0.064**

Table 7. The association of respondents' household income and KAP.

	Family Household Income	
	Chi-square test	
	Pearson chi-square	**Asymp. Sig**
Knowledge	**15.025**	**0.131**
Attitude	**9.381**	**0.496**
Practice	**9.054**	**0.338**

4. DISCUSSION

Food waste comes with considerable economic and adverse environmental effects, owing to resource losses during the production, processing, storage, distribution, and consumption stages. This study explores the management of food waste among university students by determining their knowledge, attitude, and practice. According to different studies, demographic characteristics of individuals consisting of age, family size, education level, material status, and occupation are very important in the knowledge, attitude and practice (Ghani et la, 2013; Miafodzyeva & Brandt , 2013).

Further analysis of the groups' demographic characteristics highlighted differences in family household income and gender. Ilakovac et al. (2020) found from their study that respondents who were representatives of lower-income households discarded, as expected, less food because to them buying food represented a high financial cost, and they could not afford to discard it. Moreover, according to Richter & Bokelmann (2018), women consider environmental aspects as important factors for avoiding food waste, and they also believe food is more valuable compared to men (Richter & Bokelmann, 2018). This study was fully participated by full-time university students with age ranging from 19 to 25 years old. The previous research conducted by Bravi et al. (2020) stated that younger individuals have a greater tendency to waste food than older people. However, from this study, the respondents who were young adults showed a high knowledge, attitude and practice in managing food waste.

It was crucial to evaluate the student's knowledge level, as it will influence their perception and attitude. Besides, attitude is considered along with knowledge because attitude plays a fundamental role in one's behavior. Overall, the respondents for this study scored high in the knowledge, attitude and practiced on food waste management. Previous research from Luo et al. (2019) stated that college students have inadequate knowledge and inappropriate practices about food safety, putting their health at risk from food-borne diseases. However, this study has proven the opposite result. In addition, unlike the previous study carried out by Ponis et al. (2017), the respondents in this study did not practice wasteful behaviour, leading to food waste such as purchasing items in bulk during the promotion or frequent shopping. This study was conducted to focus on food waste generation in universities because universities host

individuals with knowledge and experience who can easily foster change in their surroundings.

According to Table 3, most of the students have high knowledge on the management of food waste. However, only fifty-nine percent of the respondents know that there is law enforcement on waste segregation in certain states (Kuala Lumpur, Putrajaya, Pahang, Johor, Melaka, Negeri Sembilan, Perlis, and Kedah) in Malaysia. This study shows a similar result with a survey conducted by Malik et al. (2015) which found that their respondents (49.2%) do not know about solid waste segregation. Separation at Source Initiative (SSI) under Solid Waste and Public Cleansing Management Act 2007 (Act 672) was influential on September 2015. The initiative was believed to increase the rate of separation of waste at source and improve the national recycling rate. The public needs to sort their garbage into different bags such as paper in a blue bag, plastic in a white, glass, aluminum, and electronics in green. Leftover household waste is to be bagged and put into bins provided by the garbage companies. If those rules are failed to comply with, a fine of one thousand ringgit will be cited. It is recommended that the government take full initiative to keep the rules known and accepted by the public (Jun, 2019). Regulatory approaches, including waste reduction targets such as laws and standards, mandatory management plans, restrictions or covenants, aim to induce waste reduction and prevention behavior through penalties for actors who do not comply with regulatory provisions (Schanes et al., 2018).

A study by Jarjusey (2017) stated that 57% of respondents claim they do not know the difference between best before and use by date. However, most respondents claimed that they know the difference between best before and use-by date in this study. This kind of knowledge can give an insight if the respondents can sometimes discard food that can be consumed due to a confusion of these dates on products (Jarjusey, 2017). The minority of the respondents agreed that they frequently buy food in bulks from promotional buying, as shown in Table 5. This result was similar to the findings from Jörissen et al. (2015) which only 18.9% of the respondents were attracted to special offers in the supermarkets. According to Jörissen et al. (2015), people who are often drawn to special offers waste less food on average than people who are not interested in special offers.

The result from Table 5 suggested that 80% of the respondents only buy things when necessary. Environment Protection Agency (2009) stated in their study that 70% of respondents indicated they only purchase the amount of fruit and vegetables they needed. The majority (87%) of the respondents agreed that they checked the ‘best before’ and ‘use-by dates before purchasing regularly. Similar to the finding reported by Environment Protection Agency (2019), sixty-six percent of their respondents also checked the ‘best before’ and ‘use-by dates before purchasing. From Table 6, the result has shown that there was no significant correlation between knowledge and practice. However, this finding was quite contradictory with the findings from a study by Tsai et al. (2020), which stated a positive correlation between knowledge and practice.

For determining the association between socio-demographics and knowledge, attitude, and practice, the decision criterion is to reject the null hypothesis if the p-value is more than or equal to the level of significance ($p>0.05$). Table 7 showed that the gender and practice on food waste management was not statistically significant with a value of 0.064. This result was similar with a study by Limon et al. (2020) which found that gender was not associated with practice on food waste management. From Table 8, the result shown there was no statistically significant association between household income with knowledge, attitude, and approach on food waste management. This result was similar to a study by Limon et al. (2020), which found a significant negative association between monthly income and attitude of respondents. In addition, a study by Miafodzyeva & Brandt (2013) also showed a similar result where there was no significant association between income and food waste attitude.

5. CONCLUSION

In conclusion, the matter on food waste shall not be taken lightly as the impact is harmful to human health and the environment. By focusing the study on university students who are the future generation, we can communicate sufficient knowledge, changing attitude and practice on food waste management for better and efficient food waste management. In order to change people's waste management behaviors, waste management knowledge and awareness must be improved sustainably to the point where they can change a person's attitude and transform it into a positive action.

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CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest.

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RESEARCH ARTICLE

Diet quality and weight status of adult women at Tuba Island, Langkawi, Malaysia

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Abstract:

The prevalence of overweight and obesity in rural regions is high due to low income and limited access to nutritious foods. It is contributed by the geographical factor, which limits access to the availability of nutritious foods. Thus, this study aimed to determine the prevalence of weight status, diet quality, and its association among adult women in Tuba Island. This cross-sectional study was administered thru a structured questionnaire consisting of sociodemographic characteristics, 24-hour diet recall, and the Malaysian Healthy Eating Index (HEI). Weight and height were measured. HEI was used to identify the level of diet quality in the population. A total of 114 respondents aged between 18 to 45 years old were involved. 43% (n=49) and 26.3% (n=30) of them were overweight and obese respectively. While 28.1% (n=32) had normal weight status. The mean score of HEI was 42.44 ± 7.49, indicating poor diet quality. Further investigation showed they had poor compliance to meet dietary guidelines for vegetables, fruits, legumes, and milk and milk products. Nonetheless, diet quality was not associated with weight status in this population. The present study showed that more than half of the adult women at Tuba Island were overweight and obese, and their diet quality was poor.

Keywords: Diet quality, weight status, adult women, rural, healthy eating index (HEI)

1. INTRODUCTION

The burden of worldwide malnutrition remains a serious issue and crisis in all ages, especially among low-middle-income countries. Recently, a recognized paradox has been identified that relates poverty, food insecurity, and malnutrition to obesity or the state of overnutrition (Tanumihardjo et al., 2007). About 1.9 billion adults and one in three people worldwide are obese or overweight (World Health Organization, Global Nutrition Report), and women are the primary of it. Recent surveys indicate that the ratio of overweight or obese women among low- and middle-income countries is rising alarmingly due to ongoing demographic changes (Al Kibria et al., 2019). The higher prevalence of overweight and obesity in rural regions is due to low income and limited access to nutritious foods. Nevertheless, in many poor and rural areas, these geographical localities with limited access to the availability of healthy foods are the main problem (Canto et al., 2014). In several poor-rural areas in Malaysia, the prevalence of overweight and obesity among women was 35% and 17% in Bachok (Ihab et al., 2013), 39.6% and 11.9% in Sarawak (Chang et al., 2012), and 52.1% overweight in Sabak Bernam (Khor & Sharif, 2003).

This paradoxical circumstance occurred when the diets of people who live in poverty had enough calories to meet or exceed their energy needs but lacked the essential quality of diet that required them to have good health status and prevent chronic disease (Tanumihardjo et al., 2007). A diet high in saturated fat, added sugars, and sodium but low in fruits, vegetables, legumes, and whole grains contribute to chronic diseases (Reedy et al., 2014). Data analysis by GBD 2017 Diet Collaborators (2019) for the Global Burden of Diseases in 2017 showed that about 22% of deaths and 15% of all disability-adjusted life-years (DALYs) were caused by poor-diet quality. Diet quality is the measurement of both the quality and diversity of the whole diet, allowing the link between whole foods and health status to be explored instead of just nutrients (Preedy et al., 2013).

Tuba Island is considered a rural area where it is a traditional fishing village, and the villagers live in long-established ways. Most previous studies found that low socio-economic status and food insecurity contribute to unhealthy dietary

intake and a high prevalence of overnutrition in rural communities. In the National Plan of Action for Nutrition of Malaysia (NPANM III) 2016-2025, two additional supporting strategies were implemented which are to minimize obesity and diet-related NCDs, as well as to improve food systems for a good diet (National Coordinating Committee on Food and Nutrition, 2016). However, the extent to which women's weight status can be affected by diet quality and sociodemographic factors is still uncertain, and limited data were available from a study found in Malaysia. Thus, this study aims to assess the prevalence of weight status and diet quality among women in Tuba Island and to identify the association between sociodemographic factors and diet quality with weight status among them.

2. MATERIALS AND METHODS

2.1 Study Design and Participants

A cross-sectional study was carried out at Tuba Island, located 5km southwest of Kuah Jetty, Langkawi. There are three main villages: Kampung Tuba, Selat Bagan Nyior, and Teluk Cempedak. Convenience sampling was employed for potential respondents available to participate in this study in August 2020. Cochran's formula was used to calculate the minimum sample size. The calculation was based on the estimated prevalence of diet quality of 45.3% from a previous study in Mah Meri (Chong et al., 2019), a 95% confidence level, and 0.1 desired precision. The sample size derived was 95, but to accommodate a lower response rate of more than 35%, the sample size was increased to 129. The participants were selected by inclusion (women aged 18-45 years old, not pregnant, and not breastfeeding) and exclusion (vegetarian, developed any diseases, and changed dietary intake in the past six months). A total of 114 women were eligible to participate in this study, and data collection was conducted through a face-to-face interview which required approximately 30 minutes to complete. This study obtained ethical clearance from the Research Ethics Committee (REC) Universiti Teknologi MARA with reference number REC 05/2021 (UG/MR/421).

2.2 Research Instruments.

A structured questionnaire consisting of three sections which were demographic characteristics, anthropometry measurement, and dietary intake assessment, was used in this study. Demographic characteristics comprised four items: age, marital status, education level, and employment status. The anthropometry measurement was assessed to determine the weight and height of the respondent. The weight and height were translated to body mass index (BMI) based on WHO guidelines. Dietary intake assessment was evaluated via 24-hour diet recall (one day each from weekday and weekend) by using household measurements (teaspoons, tablespoons, rice ladles, cups, and bowls) and Atlas of Food Exchanges and Portion Sizes (Shahar et al., 2015) was used to achieve a more precise estimation of serving sizes. The Nutritionist Pro Software Version 4.0 (Axxya Systems, Stafford, Texas, USA) was used to analyze the dietary intake that was transformed into energy and nutrient intake.

The Malaysian Healthy Eating Index (HEI), established by Lee et al. (2011) and validated by Goh et al. (2012), was used to evaluate respondents' diet quality. The Malaysian HEI contained nine components, divided into seven food groups (Grains and cereals, vegetables, fruits, meat, poultry and egg, fish and seafood, legumes, milk, and dairy products) and two nutrients (percentage of energy from total dietary fat and sodium). The scoring for all components measured originated from recommended serving size and nutrient intake in the Malaysian Dietary Guidelines (MDG) (National Coordinating Committee on Food and Nutrition, 2010). The score from each food group in HEI components was computed by using the formula:

$$\frac{\text{total score accumulated from nine components}}{\text{maximum score of 90}} \times 100\%$$

The score ranges from zero to ten for each component and then was summed up to determine the total HEI score.

While the formula for composite score:

$$\frac{\text{actual serving consumed based on respondent's diet recall}}{\text{recommended serving size based on MDG}} \times 10$$

A composite score of less than 51% indicated a poor diet, a score between 51-80% stated a diet requiring improvement, and a score of more than 80% showed a good diet (Chong et al., 2019; Pei et al., 2018).

2.3 Statistical analysis

The data were analyzed using Statistical Package of Social Science (SPSS) version 23. Descriptive statistics were conducted for all variable demographic characteristics, weight status, and diet quality of the respondents, which were presented in mean, standard deviation, frequency, or percentage. Fisher's exact test was used to identify the association between sociodemographic factors and diet quality on weight status. The significant level of the statistics was set at $P<0.05$.

3. RESULTS

3.1 Sociodemographic characteristics, diet quality, and weight status

A total of 114 women participated in this study. Table 1 shows the respondent demographic characteristics, food

security status, anthropometry measurement, and diet quality status. Most were between 36-45 years old (45.6%) and were married (71.7%). Approximately half of the respondents completed secondary education (55.3%). About 66.7% were homemakers, while 21.9% and 11.4% were self-employed and worked in either the government or private sector. In terms of diet quality status, 86% of the respondents had a poor diet, while another 14% fell under a diet requiring improvement classification. None of the respondents achieved a good diet category under the Malaysian HEI classification. A high prevalence of overweight with 43.0% was seen among the respondents, followed by normal, obese, and underweight, with 28.1%, 26.3%, and 2.6%, respectively.

Table 1: Sociodemographic characteristics, diet quality status, and anthropometry measurement of respondents (n=114)

Variables	n	%	Mean ± SD
Sociodemographic characteristics			
Age, years			
18-26	33	28.9	
27-35	29	25.4	
36-45	52	45.6	
Marital Status			
Single	27	23.7	
Married	81	71.1	
Widowed/divorced	6	5.3	
Education Level			
No formal education	3	2.6	
Primary education	37	32.5	
Secondary education	63	55.3	
Tertiary education	11	9.6	
Employment Status			
Government/private sector	13	11.4	
Self-employed	25	21.9	
Housewife	76	66.7	
Diet quality status			
[a]HEI classification			
< 51% (poor diet)	98	86.0	
51-80% (diet requiring improvement)	16	14.0	
> 80% (good diet)	0	0.0	
Anthropometry measurement			
Weight, kg			67.89 ± 14.89
Height, cm			157.39 ± 5.54
Body mass index, kg/m^2			27.36 ± 5.55
< 18.5 (underweight)	3	2.6	
18.5-24.9 (normal)	32	28.1	
25-29.9 (overweight)	49	43.0	
> 30 (obese)	30	26.3	

[a]Healthy Eating Index

3.2 Malaysian Healthy Eating Index (HEI)

Table 2 presents the mean serving size consumed in a day and the mean score for each component of Malaysian HEI of the respondents in this study. The total mean score of Malaysian HEI was 42.44 ± 7.49 indicating poor diet among women on Tuba Island. The majority of them were not able to meet the recommended serving size of vegetables (0.76 ± 1.09), fruits (0.15 ± 0.49), legumes (0.14 ± 0.07), and milk and milk products (0.0575 ± 0.21). Only cereals and grains (6.75 ± 3.14) and poultry, meat, and egg (0.83 ± 0.69) fulfilled the recommended serving size for one day. The mean percentage of energy from total dietary fat (33.10 ± 4.95) and sodium intake (2383.46 ± 886.25) exceeded the recommendation. We found out that fish and seafood intake (1.43 ± 0.89) were more than the dietary guidelines due to sustainable foods among island people.

Table 2: Serving size per day, the score for each component, and total HEI (n=114)

HEI component	[a]Recommended serving size/day	Serving size/day (Mean ± SD)	Possible Range of Score	HEI Score (Mean ± SD)
Food groups				
Cereals and grains	4 – 8	6.75 ± 3.14	0 to 10	8.20 ± 2.79
Vegetables	3	0.76 ± 1.09	0 to 10	2.13 ± 2.57
Fruits	2	0.15 ± 0.49	0 to 10	0.68 ± 2.09
Poultry, meat and egg	0.5 – 2	0.83 ± 0.69	0 to 10	6.59 ± 3.84
Fish and seafood	1	1.43 ± 0.89	0 to 10	8.66 ± 2.86
Legumes	0.5 – 1	0.143 ± 0.07	0 to 10	0.19 ± 1.07
Milk and dairy products	1 – 3	0.0575 ± 0.21	0 to 10	0.28 ± 1.25
Nutrients				
Percentage of energy from dietary fat, %	≤30	33.10 ± 4.96	0 to 10	4.07 ± 4.07
Sodium, mg	≤2000	2383.46 ± 886.25	0 to 10	7.33 ± 2.89
Total [b]HEI, %			0 to 100	42.44± 7.49

[a]Based on Malaysian Dietary Guidelines (National Coordinating Committee on Food and Nutrition, 2010)
[b]Healthy Eating Index

3.3 Association between sociodemographic characteristics and diet quality status with weight status

Table 3 depicts the association between education level, employment status, and diet quality with weight status. Education level (p=0.010) and employment status (p=0.002) were significantly associated with weight status. However, a non-significant association was found between diet quality and weight status among adult women on Tuba Island (p=0.390).

Table 3: Association between sociodemographic characteristics and diet quality with weight status (n=114)

Variables	<18.5 kg/m^2 (Underweight), n=3		18.5-24.9 kg/m^2 (Normal), n=32		25-29.9 kg/m^2 (Overweight), n=49		>30 kg/m^2 (Obese), n=30		p-value
	n	%	n	%	n	%	n	%	
Education level									
No formal education	0	0.0	1	33.3	2	66.7	0	0.0	[a]0.010*
Primary education	0	0.0	5	13.5	19	51.4	13	35.1	
Secondary education	1	1.6	25	39.7	24	38.1	13	20.6	
Tertiary education	2	18.2	1	9.1	4	36.4	4	36.4	

Employment status									
Government/private sector	1	7.7	4	30.8	8	61.5	0	0.0	[a]0.002*
Self-employed	0	0.0	12	48.0	4	16.0	9	36.0	
Housewife	2	2.6	16	21.1	37	48.7	21	27.6	
Diet quality status									
Poor diet	2	66.7	26	81.3	45	91.8	25	83.3	
Diet need improvement	1	33.3	6	18.8	4	8.2	5	16.7	[a]0.390

[a]Fisher's Exact Test
*Significant value ($p<0.05$)

4. DISCUSSION

Findings in this study showed that women on Tuba Island had a high prevalence of weight status (overweight and obese). Surprisingly, it was consistent with data from World Health Organization (WHO) which is 40% overweight and 15% obese, respectively (World Health Organization). Along with economic development and income growth among developing countries, the number of overweight and obese people is rising. This relationship occurs when processed foods' availability and low cost comprise 'empty calories and no nutritional value. A similar study by Befort et al. in 2012 indicated that in developing countries, rural women were affected by higher rates of weight gain and obesity. This finding is related to woman's lifestyle availability of fast and processed food, sedentary or less physically active lifestyle, and consumption of an energy-rich but nutrient-poor diet, which result in a high number of obesities among them.

Overall, women on Tuba Island had a poor diet with a higher Malaysian HEI mean score, and it was similarly reported in the previous study conducted among Mah Meri ethnic women (Chong et al., 2019). Poor diet in this study was contributed by low scores on the consumption of vegetables, fruits, legumes, and milk. These results were consistent with studies conducted by Badari et al. (2013) and Chong et al. (2019), particularly those unable to comply with recommended dietary intake. Respondents reported low consumption of these food groups due to lack of availability and high food prices on this island. A possible reason, as the area is geographically isolated from others, is that a boat is needed to obtain an adequate food supply for the island community. In contrast, HEI scores in other Malaysian urban areas fell into the 'need improvement' category (Karupaiah et al., 2012; Pondor et al., 2017) that, were attributed to high income and stable financial status that will affect food choices available in these areas. Concerning low economic status, high food costs seemed to have a particular effect on the affordability of households to spend a large proportion of their income on food (Brinkman et al., 2009; Gustafson, 2013).

Despite poor diet quality, the respondents had a substantially higher consumption of fish and seafood, probably due to easy access to adequate protein sources as they lived on the island and most of their family members worked as fishermen. The findings were in line with previous studies where most islanders had a high proportion of consuming fish or/and seafood due to engaging in traditional fishing activity (Farmery et al., 2020; Haynes et al., 2020; Horsey et al., 2019). The average consumption of poultry, meat, and eggs is associated with an agricultural activity that emphasizes the availability of these products. As for nutrient components, excessive amounts of fat and sodium from recommendations were due to high consumption of cooking or purchasing more fried foods, coconut milk, and soy sauce dishes. From the dietary assessment, most of them were frequently consumed like nasi lemak, fried chicken/fish, chicken/fish curry, chicken/fish cooked in soy sauce/sambal, fried noodles, fried rice, traditional rice *kuih*, and salted fish. Thus, it is unsurprising that the lowest-cost diets significantly cause the least healthy (Darmon & Drewnowski, 2008).

The present study found a significant association between education and employment status with weight status. A total of 86.5% of respondents who completed primary education were overweight and obese. Education is related to increasing knowledge related to nutrition; therefore, those who have a higher education have better exposure to nutrition knowledge which will result in engaging in healthy dietary habits. Chong et al. (2019) mentioned that women with lower education usually had poor nutrition knowledge and low awareness and comprehension of nutrition information. In contrast, 76.3% of unemployed women in Tuba Island contribute to numbers overweight/obesity. Employment showed varying impacts on obesity by age and gender and unemployment among women and is associated with increased BMI (Noh et al., 2016). It could be explained by low physical activity and unhealthy dietary intake.

Overall, women who are overweight/obese were associated with diet quality (Wolongevicz et al., 2009). However, this study identified no association between diet quality and weight status. A systematic review by Asghari et al. (2017) found that 24-hour diet recall cannot obtain estimated dietary patterns and usual intake. It is consistent with our study that used 24-hour diet recall to assess respondents' dietary intake. Besides, the number of respondents engaged in this study was low compared to other reviewed studies.

The findings from this study can represent the primary data on diet quality and weight status for women on Tuba Island. However, due to the small sample size, it cannot conclude a causal inference. A multicentre approach may be applied in future research to represent Malaysian rural and island populations from other areas. The longitudinal research design may be adopted, and qualitative analysis could further explore diet quality and weight status by using in-depth interviews utilizing open-ended questions that could allow for a deeper exploration of these measures.

5. CONCLUSION

The finding highlights poor diet quality and a high prevalence of overweight and obesity among adult women at Tuba Island, Langkawi. Two sociodemographic variables, education and employment, were associated with weight status, but no association was found between diet quality and weight status. This research emphasized diet quality and weight status from women's viewpoint in the Malaysian rural area. These findings could help health-related agencies, government ministries, and other stakeholders develop educational, promotion, prevention, and treatment programs to improve diet quality and reduce overweight and obesity incidence among women in Malaysia, especially in rural areas. However, more research needs to be conducted to identify other causes of poor diet quality and the high prevalence of overweight and obesity. Improved diet quality and weight status will enhance health and improve quality of life.

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RESEARCH ARTICLE

Prevalence and risk factors associated with burnout among occupational therapists

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Abstract:

Occupational therapist (OT) is at risk of developing burnout due to high cognitive demand in job tasks and the complexity of the practice environment. In Malaysia, the prevalence and the extent of burnout levels among OTs remained in question due to no documented scientific evidence being available. This study aimed to examine the prevalence of burnout among OTs in Malaysia and its associated factors. A cross-sectional study was carried out via an online survey using the Malay version of the Copenhagen Burnout Inventory (CBI-M). The findings showed that OTs in Malaysia were vulnerable to burnout conditions with 69.4% reporting at least one burnout condition (n=108) where Greater Personal Burnout (65.7%) followed by Work-related Burnout (62.0%) and Client-related Burnout (52.8%) were reported. The burnout levels were shown to have a significant association with age and years of working experience ($p < 0.05$). Meanwhile, the Client- related burnout, in particular, was shown to have differences with marital status. In conclusion, interventions and prevention programs related to burnout should be emphasized and executed at all levels of management to promote better occupational well-being among OTs in Malaysia.

Keywords: Burnout, Copenhagen Burnout Inventory(CBI-M), Occupational Therapist, Risk Factor

1. INTRODUCTION

Burnout is a syndrome characterized by feelings of exhaustion, greater mental distance or cynicism toward work, and a decrease in professional efficacy, which resulted from chronic work-related stress that has not been managed properly (WHO, 2019). Recent studies on the causes of burnout among workers have found that both workplace-related and demographic factors can contribute to burnout. According to a study by Zhou et al. (2020), workplace issues such as a hostile work environment, unreasonable workload expectations, and a lack of work-life balance are strongly linked to burnout. In terms of demographic factors, a study of burnout by Gashmard et al. (2015) showed that burnout has a significant association with gender, educational level, and the place and condition of one's residence.

Burnout has been widely recognized as an occupational hazard to both human service professionals (Huang et al., 2021; Tabor, 1984) and healthcare professionals (Adwan, 2014; O'Connor, Neff & Pitman, 2018) such as occupational therapists (OT). OT works with a lot of people from all walks of life and that can be challenging as humans are complex beings with distinctive values, beliefs and personalities.

Apart from that, OT is also considered a burnout-causing profession because of its high demand for knowledge and cognitive resources such as problem solving and creativity (Derakhshanrad, Piven & Zeynalzadeh Ghoochani, 2019) in order to promote, support or improve the functionality of their client in daily life activities (Katsiana et al., 2021).

Studies regarding burnout among occupational therapists have been conducted worldwide including in countries like Greece, Turkey, Spain, Philippines, and Portugal (Katsiana et al., 2021; Abaoğlu, Demirok & Kayıhan, 2020; Escudero-Escudero, Segura-Fragoso & Cantero-Garlito, 2020; Delos Reyes, 2018; Reis et al., 2018). As of now, there was currently no documented evidence of such a study has been conducted in Malaysia yet. Like other occupational therapists around the world, occupational therapists in Malaysia also have the potential risk of developing occupational burnout due to the complex nature of the profession and cognitive-demanding job tasks. However, the prevalence and the extent of burnout levels remained in question due to no documented scientific evidence being available. Because of this, there was a lack of awareness regarding the issue of burnout among occupational therapists in Malaysia. This study aimed to explore the prevalence of burnout among occupational therapists that are currently working in Malaysia. The findings from this study can potentially act as an initiator to increase awareness regarding burnout among occupational therapists in Malaysia by acknowledging the risk of burnout and underlining the need for a strategy to overcome this issue.

2. MATERIALS AND METHODS

Data collection procedure

This cross-sectional study was executed after being granted ethical approval (FERC/FSK/MR/2022/0109) from the Ethics Committee of the Health Sciences Faculty, Universiti Teknologi MARA (UiTM). A total of 108 (n=108) occupational therapists fulfilled the inclusion criteria and were recruited via purposive sampling in this study. The inclusion criteria for this study include; (1) occupational therapist working in the central region part of Malaysia (Selangor, Kuala Lumpur and Putrajaya) (2) at least one year of working experience, while the exclusion criteria include: (1) occupational therapist working outside of central region part of Malaysia (2) diagnosed with mental illness. Participants in this study were contacted through online platforms such as WhatsApp, Facebook and email, and the data were collected using an online questionnaire. After participants have given their consent to take part in the study, an online survey was used to administer a self-reported questionnaire.

Instrument

The questionnaire used in this study consisted of two sections: Section 1: Demographic Data of participants and Section 2: Malay version of the Copenhagen Burnout Inventory (CBI-M) that has been translated, validated, and adapted for the Malaysian population by Chin et al. (2018). The questionnaire was distributed through several online platforms such as WhatsApp, Facebook and email using Google Form. Participants were required to answer all questions as responses for all items in both sections were mandatory.

Data Analysis

The data gathered was analyzed using the Statistical Package for the Social Sciences (SPSS) version 26. To describe the variables derived from the demographic data, descriptive analyses (frequency, percentage, mean) were carried out. On the other hand, the Kruskal-Wallis H test and Spearman's test were used were carried out to determine the association between burnout levels and demographic variables such as age, years of work experience, the number of children, and marital status.

3. RESULTS AND DISCUSSION

3.1 Results

Table 1 shows the characteristics of the sample in this study. A total of 108 (n=108) occupational therapists (25.0% men and 75.0% women) participated in this study. The mean (SD) age of the participants was 33.53(6.84) years and the age ranged from 24 to 57 years old. More than half of the participants were aged between 24 and 33 years old, 68 (63.0%). The majority were married 57 (52.8%) and had 1 or more children 60 (55.6%). About half (58, 53.7%) of the participants were working in the hospital setting. Twenty-five (23.1%) of the participants were practising primary health care, while the majority, 44 (40.7%), had been in service as an occupational therapist between 1 to 5 years. Most of the participants (48, 44.4%) were working in Selangor.

Table 1. Distribution of the sample's characteristics (n = 108)

Variable		Frequency	%
Gender	Male	27	25.0
	Female	81	75.0
Age	24 – 33	68	63.0
	34 – 43	30	27.8
	44 – 53	8	7.4
	> 53	2	1.9
Marital Status	Single	40	37.0
	Married	57	52.8
	Divorced / Separated	7	6.5
	Widow / Widower	4	3.7
No. of Children	0	48	44.4
	≥ 1	60	55.6
Work Setting	Hospital	58	53.7
	Health Clinic	26	24.1
	Community Centre	2	1.9
	Private Centre	22	20.4
Area of Practice	Primary Health Care	25	23.1
	Psychiatry	7	6.5
	Pediatric	20	18.5
	Orthopaedic	14	13.0
	Geriatric	10	9.3
	Neuromedical / Brain Injury	17	15.7
	Surgical / Burn	3	2.8
	RTW / RTD	8	7.4
	Spinal / Amputee	3	2.8
	Palliative Care	1	.9
Location of Service	Selangor	48	44.4
	Kuala Lumpur	35	32.4
	Putrajaya	25	23.1
Years of Experience as an OT	1-5	44	40.7
	6-10	32	29.6
	11-15	16	14.8
	16-20	10	9.3
	21-25	5	4.6
	>25	1	.9

A total of 75 (69.4%) participants perceived to have symptoms of at least one burnout condition. Of the total sample shown in Table 2, 71 (65.7%) had symptoms of Personal Burnout (PB), 67 (62.0%) had symptoms of Work-Related Burnout (WB), and 57 (52.8%) had symptoms of Client Related Burnout (CB). The most common isolated burnout condition among the participants was PB (5, 4.6%), followed by WB (3, 2.8%) and CB (1, 0.9%). Twelve (11.2%) of the participants presented symptoms of two burnout conditions, with the most common being the combination of PB and WB, which accounted for 10 (9.3%) of the participants. Fifty-three (50%) of the participants experienced symptoms of PB, WB, and CB simultaneously.

Table 2: Prevalence of burnout levels in the sample of Malaysian occupational therapists

	Presence		Absence		Mean	SD
	n	%	*n*	%		
PB	71	65.7	37	34.3	58.06	24.69
WB	67	62.0	41	38.0	56.05	23.29
CB	57	52.8	51	47.2	50.39	28.03

The correlation between age and the three dimensions of burnout was found to be weak but positive and statistically significant: PB (r = .276, p = .04), WB (r = .231, p = .016), CB (r = .302, p = .01). The value of the correlation was positive, it was inferred that burnout levels increase with age. The correlation between years of working experience and the three dimensions of burnout was also found to have weak but positive and significantly correlated with all three levels of burnout: PB (r = .269, p = .005), WB (r = .203, p = .035), CB (r = .253, p = .008). The value of the correlation was also positive, it can be inferred that burnout levels also increase with years of working experience. As for the number of children, there was no significant correlation found between the number of children that the participants have and their burnout levels.

Table 3: Association between demographic variables (age, years of working experience, number of children) with 3 dimensions of burnout

	PB		WB		CB	
	p	r	*p*	r	*p*	r
Age	.004*	.276	.016*	.231	.001*	.302
Years Working experience	.005*	.269	.035*	.203	.008*	.253
Number of children	.377	.086	.437	.076	.160	.136

*Correlation: (p,0.05) statistical test: Spearman's Correlation

The differences between levels of burnout and marital status revealed a non-significant difference between the levels of PB and WB across the four groups of marital status. However, there is a statistically significant difference in the level of CB across the four groups of marital status, X2 (3, n=108) =9.604, p=0.022. Further comparison within the marital status group using Pairwise comparisons revealed significant differences between groups 1(single) and 4 (widow/widower), and groups 2 (married) and 4 (widow/widower), where p = 0.05.

Table 4: Difference between marital status with the three dimensions of burnout

	Marital Status	N	Mean	SD	Mean Rank	X2	P-value
PB	Single	40			52.55	3.507	0.320
	Married	57			52.96		
	Divorced / Separated	7	1.77	0.731	63.86		
	Widow / Widower	4			79.63		
WB	Single	40			54.75	5.284	0.152
	Married	57			51.21		
	Divorced / Separated	7	1.77	0.731	61.29		
	Widow / Widower	4			87.00		
CB	Single	40			51.28	9.604	0.022
	Married	57			52.15		
	Divorced / Separated	7	1.77	0.731	67.36		
	Widow / Widower	4			97.75		

*Difference; (p,0.05) statistical test; Kruskal Wallis

Table 5: Pairwise comparisons of Marital status

	Test Statistic	Sig.
Single-Married	-.874	.892
Single-Divorced / Separated	-16.082	.209
Single-Widow / Widower	-46.475	.005
Married-Divorced / Separated	-15.208	.224
Married-Widow / Widower	-45.601	.005
Divorced / Separated-Widow / Widower	-30.393	.121

3.2 Discussion

Prevalence of burnout syndrome and burnout levels among occupational therapists in the central region of Malaysia

Malaysian occupational therapists were shown to be vulnerable to high burnout conditions as indicated by previous research done concerning occupational therapists in other countries (Katsiana et al., 2021, Anyfantis et al., 2020; Escudero-Escudero, Segura- Fragoso & Cantero-Garlito,2020; Abaoğlu, Demirok & Kayıhan, 2020; Reis et al., 2018). These findings can be interpreted based on the complex and demanding role of occupational therapists. As stated by Derakhshanrad, Piven & Zeynalzadeh Ghoochani (2019), occupational therapists are among the professionals in healthcare that are at risk of high occupational burnout due to the high knowledge-related job demand in terms of problem-solving and creativity.

In terms of burnout levels, results from this study showed that Malaysian occupational therapists are more likely to have burnout, especially concerning PB (65.7%) and WB (62.0%). Another study utilizing Copenhagen Burnout Instrument (CBI) by Reis et al. (2018) also reported that occupational therapists in Portugal showed greater burnout concerning WB (44.7%) and PB (43.6%). The similarity in results could indicate that PB and WB are more common among occupational therapists compared to CB. Previous research conducted in other countries such as Greece, Turkey and Spain (Katsiana et al., 2021; Abaoğlu, Demirok & Kayıhan, 2020; Escudero-Escudero, Segura-Fragoso & Cantero-Garlito, 2020) also shows high levels of burnout among occupational therapists but unfortunately, the results cannot be compared, because the measurements were made with different burnout tools from what was used in this study.

Association between the prevalence of burnout syndrome with demographic variables (age, years of working experience, number of children) among occupational therapists in the central region of Malaysia

This study showed that higher rates of burnout were significantly associated with the increased age of occupational therapists. This finding was in line with the majority of previous studies that found a significant association between age and burnout levels in occupational therapists (Anyfantis et al., 2020; Escudero-Escudero, Segura-Fragoso & Cantero-Garlito, 2020; Delos Reyes. 2018; Reis et al. 2018; Bruschini, Carli & Burla, 2018). As mentioned by Reis et al. (2018), the association between age and burnout levels could confirm the underlying deterioration and challenges concerning people's ability to adapt to life changes as they age.

Apart from age, higher rates of burnout were also significantly associated with more years of work as occupational therapists. Such findings were also reported by previous studies by Anyfantis et al. (2020) in Greek, Reis et al. (2018) in Portugal, Poulsen et al. (2014) in the United Kingdom, and Mozayan et al. (2012) in Iran. As confirmed by Duli (2016), years of working experience are considered an important predictor of professional burnout characterized by an increased level of exhaustion, more negative emotions toward work, and less perception of success concerning work.

As opposed to what was reported in previous studies (Escudero-Escudero, Segura-Fragoso & Cantero-Garlito, 2020; Katsiana et al., 2021), findings from this study showed that higher rates of burnout were not significantly associated with the number of children that the therapist had. Further research should be conducted to identify any plausible causes for the differences in the results.

Difference between the prevalence of burnout syndrome with demographic variable (marital status) among occupational therapists in the central region of Malaysia

Regarding the association between burnout levels and marital status, significant differences were observed concerning client-related burnout (CB) while no differences were observed with regard to personal burnout (PB) and work-related burnout (WB). Further comparison within the group of marital status revealed that the differences in CB were observed between groups of therapists who were single and therapists who have lost their spouses, and also between groups of therapists who were married and therapists who have lost their spouses. Although this finding is in agreement with previous studies (Anyfantis et al., 2020; Escudero- Escudero, Segura-Fragoso & Cantero-Garlito, 2020; Delos Reyes, 2018), which stated that marital status was one of the demographic variables associated with burnout, however, it is worth saying that testing using a larger sample size is required in the future research due to the very small number of occupational therapists belonging to the "Widow/Widower" group in comparison to the other groups within the marital status observed in this study.

4. CONCLUSION

The consistency in the prevalence rate of burnout conditions observed in this study and the vast majority of previous studies showed that occupational therapists are indeed at risk of high occupational burnout. Furthermore, the burnout level found out associated with age and years of working experience. Thus, it is very crucial to provide this profession with the appropriate coping mechanism and protection it needed. Interventions and preventive programs related to burnout among occupational therapists in Malaysia should be emphasized and executed at all levels of management to get the best possible outcome.

For future studies, using a larger sample size and more inclusive of all states in Malaysia is highly recommended to get the closest representation regarding the prevalence of

burnout experienced by the population of occupational therapists in Malaysia. It is also recommended to do more in-depth factors underlying burnout among occupational therapists in Malaysia by using a qualitative type of study in the future.

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RESEARCH ARTICLE

Musculoskeletal disorders (MSD), stress, and elements of home environment among health sciences students in Malaysia

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Abstract:

The COVID-19 pandemic has impacted Malaysia's education system where the learning medium shifted from face-to-face to online learning platforms. Consequently, it might impact students' stress levels and the prevalence of musculoskeletal disorders (MSD). In addition, the difference in home elements might influence the development of MSD. This study aimed to determine the prevalence of MSD and stress levels. Furthermore, to investigate the association between MSD with elements of the home environment. One hundred and thirty-six (n=130) health sciences students around Malaysia participated in this study. A cross-sectional study was carried out via an online survey using the Cornell Musculoskeletal Discomfort questionnaire (CMDQ) and Stress Student Inventory (SSI). More than 30% of participants reported the presence of MSD in almost all body parts. The majority of participants reported having mild stress (57.7%). The presence of MSD in 20 body parts showed a significant association ($p<0.05$) with physical, interpersonal relationships, academic, and environmental stress. Moreover, the presence of MSD in 7 body parts showed significant differences ($p<0.05$) with elements of the home environment. In conclusion, health sciences students have a high prevalence of MSD and the development of MSD was associated with stress and elements of the home environment.

Keywords: Musculoskeletal disorders, Stress, Health Sciences students.

1. INTRODUCTION

The COVID -19 pandemic was an ongoing global rating crisis and has impacted millions of people worldwide regardless nationalities, genders, ages, income levels, and educational levels (Zu et al., 2020). All Malaysian higher education institutions whether public or private institutions were required to postpone all learning programs and online education became the preferred methodology for educators. An online education platform became the preferred methodology for educators such as Google Meet, Microsoft Teams, etc (Mamat, 2020; Yusuf, 2020). Students are restrained in their homes or hostels and they use laptops, computers, or mobile phones to access educational materials, such as assignments or study materials and this might expose them to the development of musculoskeletal disorders (MSDs) due to repetitive movement while using this equipment (Katz et al., 2000; Shobhit Mahajan, 2020).

MSDs were defined as body structure impairment, including muscles, tendons, nerves, ligaments, bones, joints, and blood circulation systems (Podniece, 2008). Studies have shown that MSDs were highly prevalent among medical and other health sciences students, ranging from 45.7% to 80.0% as it affects various body regions which are the neck, upper back, wrist or hand, low back, shoulder, and elbow or forearm (Smith & Leggat, 2004; Alshagga et al., 2013; Smith et al., 2014; Abledu & Offei, 2015; James et al., 2018; Wami et al., 2020).

Psychological risk factors may have the same effect on MSDs as physical risk factors (Warren,2010). Psychological disorders such as anxiety, high level of stress, and depression have been involved in the development of MSDs (Nahit et al., 2003; Magnavita et al., 2011). Stress is an emotional imbalance that can occur because of various factors such as academic pressure, the nature of one's desired career, financial considerations regarding school, and future work chances (Rana et al.,2019). A conducive home environment is one of the crucial components of online learning. The significant challenges associated with online learning are unconducive physical space, environment, and mental health-related issues (Mseleku, 2020). Students are unable to concentrate on their coursework in the absence of a favourable learning environment which can cause study performance to drop as a result of unconducive home environment during lockdown implemented (Kapasia et al. (2020); Wenjun et al., 2020).

Most of the studies conducted confined their study population to non-health science students and a single academic program ~~only~~. Then, for health science students, the researcher only focused on nursing students, although there were various health science programs such as physiotherapy, occupational therapy, dietetics, etc (Smith & Leggat, 2004; Alshagga et al., 2013; Smith et al., 2014; Abledu & Offei, 2015; James et al., 2018; Wami et al., 2020). There are limited studies focusing on the stress level, elements of the home environment, the relationship between MSD with stress, and elements of the home environment among health sciences students in Malaysia (Grimes et al., 2004; Alshagga et al., 2013; Smith et al., 2014; Abledu & Offei, 2015; Heidari et al., 2018; James et al., 2018; Wami et al., 2020; Hendi et al., 2021). Therefore, this study aims to investigate the prevalence of MSD and the level of stress among health sciences students in Malaysia. Besides, this study also attempts to determine the association between the level of stress and elements of the home environment with the prevalence of MSD among health sciences students in Malaysia.

2. MATERIALS AND METHODS

Data collection procedure

This cross-sectional study was executed after being granted ethical approval (FERC/FSK/MR/2021/1146) from the Ethics Committee of the Health Sciences Faculty, University Technology MARA (UiTM). A total of 130 (n=130) health sciences students fulfilled the inclusion criteria and were recruited via purposive sampling in this study. The inclusion criteria for this study include; (1) full-time undergraduate health sciences student (2) does not have any medical diagnosis or any musculoskeletal disease while the exclusion criteria include: (1) less than 1 semester/year being a full-time student. Participants have given their consent to take part in the study, an online survey was used to administer a self-reported questionnaire.

Instrument

The questionnaire used in this study consisted of three sections: Section 1: Demographic Data of participants and information of participant's home environment, Section 2: Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) and Section 3: Student Stress Inventory (SSI). The questionnaire was distributed through several online platforms such as WhatsApp, Instagram, and Telegram using Google Forms. Participants were required to answer all questions as responses for all items in all three sections.

Data Analysis

The data gathered was analyzed using the Statistical Package for the Social Sciences (SPSS) version 26. To describe the variables derived from the demographic data, descriptive analyses (frequency, percentage, mean) were carried out. On the other hand, the Kruskal-Wallis H test was carried out to find the differences between the prevalence of MSD with demographic variables (elements of the home environment).

3. RESULTS

The age of the participants of this study ranged from 19-31 years old. Females constituted 86.20 % of the participants (n=112) while the males formed 13.80% (n=18). Seventy-six

point two percent of the participants (n=99) were studying in public universities and 49.20% (n=64) of the study population were studying at Universiti Teknologi MARA (UiTM). Besides that, 39.20% (n=51) of the study population were studying occupational therapy programs and 25.40% of the participants were in semester 8 of their current semester as shown in Table 1.

Table 1: Summaries of demographic data

Variables	Frequency (n)	Percentage (%)
Gender		
Male	18	13.80
Female	112	86.20
Age		
19- 21	28	21.50
22-24	93	71.50
25 -27	7	5.40
28- 31	2	1.50
Type of University		
Public University	99	76.20
Private University	31	23.80
Name of University		
Universiti Teknologi Mara (UiTM)	64	49.20
Universiti Kebangsaan Malaysia (UKM)	8	6.20
Universiti Sultan Zainal Abidin (UniSZA)	13	10.00
Universiti Sains Malaysia (USM)	10	7.70
Universiti Putra Malaysia (UPM)	4	3.10
Universiti Selangor (UNISEL)	8	6.20
Universiti Tunku Abdul Rahman (UTAR)	6	4.60
Perdana University	5	3.80
KPJ Healthcare University College	12	9.20
Programmed		
Occupational Therapy	51	39.20
Physiotherapy	15	11.50
Nutrition and Dietetics	13	10.00
Optometrist	4	3.10
Environment Health and Safety	16	12.30
Medical Laboratory Technology	13	10.00
Nursing	5	3.80
Medical Imaging	13	10.00
Current Semester		
Semester 2	9	6.90
Semester 3	21	16.20
Semester 4	18	13.80
Semester 5	17	13.10
Semester 6	21	16.20
Semester 7	11	8.50
Semester 8	33	25.40

Table 2: Summaries of the participant's demographic variable (Elements of Home Environment)

Variable	Frequency (n)	Percentage (%)
Do you have a conducive/ ergonomic study station and good elements of the home environment		
Yes	78	60.0
No	82	40.0
Described study station according to the statement below:		
Has good lighting during the daytime, which natural light from the sun		
Absent	46	35.4
Present	84	64.6
Use a static chair and/or static table		
Absent	49	35.4
Present	84	64.6
Has own room or private place		
Absent	55	42.30
Present	75	57.70

The participant's home environment elements are illustrated in Table 2 and 60% (n=78) of participants have conducive or ergonomic study stations and good aspects of the home environment. However, 40% (n=52) of participants do not

have a conducive or ergonomic study station and a good element of a home environment. In addition, 64.6% (n=84) of the study population had good lighting during the daytime, which was natural light from the sun, 62.3% (n=81) of the study population were using the static chair and/or static table, and 57.7% (n=75) had own room or private place.

Table 3 showed the prevalence of MSD present in the body region. More than 40% of participants (n=61) claimed the presence of discomfort in their neck region. It is also the highest prevalence of MSD among all body parts. The right foot region had the least complaints by the study population, about 24.6% (n=32).

Table 3: Prevalence of MSD over each body region

Body region	Frequency (n)	Percentage (%)
Neck	61	46.90
Right shoulder	50	38.50
Left shoulder	54	41.50
Upper back	49	37.70
Right upper arm	46	35.40
Left upper arm	47	36.20
Lower back	37	28.50
Right forearm	44	33.80
Left forearm	44	33.80
Right wrist	41	31.50
Left wrist	43	33.10
Hip/buttock	43	33.10
Right thigh	37	28.50
Left thigh	41	31.50
Right knee	45	34.60
Left knee	46	35.40
Left lower leg	39	30.00
Right lower leg	41	31.50
Right foot	32	24.60
Left foot	33	25.40

Figure 1 showed the level of stress experienced by the participants. Present in upper body parts. More than 50% of participants (n=75) experienced mild stress, 41.50% (n=54) of the participants experienced moderate stress, and 0.80% (n=1) has severe stress.

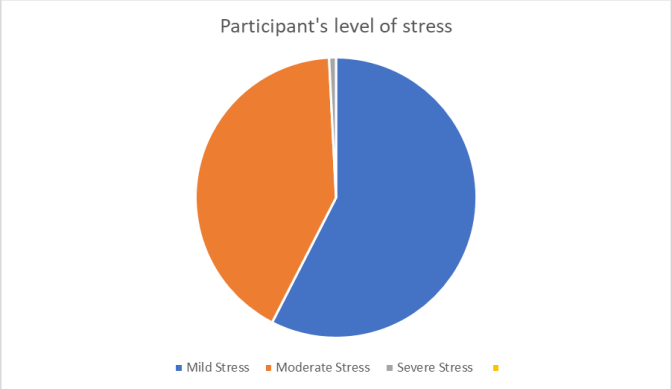

Figure 1. Participant's Level of Stress

The result in Table 4 showed there are significant differences between MSD and elements of the home environment which has good lighting during the daytime. For example, natural light from the sun, including left upper arm (x^2= 0.107, p=0.030), lower back (x^2= 0.000, p=0.010), right forearm (x^2= 1.258, p=0.002), left wrist (x^2= 4.604, p=0.032), hip/ buttock (x^2= 4.406, p=0.0.36), right foot (x^2= 6.390, p=0.010), and left foot (x^2= 6.063, p=0.010). There is no significant difference between MSD with good lighting during daytime. For example, natural light from the sun, including the neck, right shoulder, left shoulder, upper back right upper arm, left forearm, right wrist, right and left thigh, right and left knee, and right and left lower leg.

The result in Table 5 showed there is significant differences between MSD and element of the home environment using a static chair and/or table, including the left shoulder (x^2= 3.668, p=0.050) and left upper arm (x^2= 3.867, p=0.040). There is no significant difference between MSD with using a static chair and/or table, including neck, right shoulder, upper back, right upper arm, lower back, left and right forearm, right and left wrist, hip/ buttock, right and left thigh, right and left knee, left and right lower leg, and right and left foot.

The result in Table 6 showed there are non-significant differences between MSD and elements of the home environment which has their room or private place, including neck, right and left shoulder, upper back, right and left upper arm, lower back, right and left forearm, right and left wrist, hip/buttock, right and left thigh, right and left knee, right and left lower leg and right and left foot.

Table 4: Differences between MSD with elements of home environment (Has good lighting during daytime)

Variable	Frequency (n)	x^2	p- value (p)
Neck	130	0.107	0.740
Right shoulder	130	0.000	0.980
Left shoulder	130	1.258	0.260
Upper back	130	0.355	0.550
Right upper arm	130	0.741	0.380
Left upper arm	130	0.107	0.030*
Lower back	130	0.000	0.010*
Right forearm	130	1.258	0.002*
Left forearm	130	2.421	0.120
Right wrist	130	0.004	0.940
Left wrist	130	4.604	0.032*
Hip/ buttock	130	4.406	0.036*
Right thigh	130	1.688	0.190
Left thigh	130	2.721	0.090
Right knee	130	3.145	0.070
Left knee	130	2.540	0.110
Left lower leg	130	3.108	0.070
Right lower leg	130	3.465	0.060
Right foot	130	6.390	0.010*
Left foot	130	6.063	0.010*

*Difference;(p<0.05) statistical test; Kruskal Wallis

Table 5: Differences between MSD with elements of home environment (Using static chair and/or table)

Variable	Frequency (n)	x^2	p- value (p)
Neck	130	0.069	0.790
Right shoulder	130	2.033	0.150
Left shoulder	130	3.668	0.050*
Upper back	130	0.009	0.920
Right upper arm	130	2.144	0.140
Left upper arm	130	3.867	0.040*
Lower back	130	0.220	0.630
Right forearm	130	0.869	0.350
Left forearm	130	0.098	0.750
Right wrist	130	1.338	0.240
Left wrist	130	0.057	0.810
Hip/ buttock	130	0.535	0.460
Right thigh	130	0.430	0.510
Left thigh	130	0.460	0.490
Right knee	130	1.418	0.230
Left knee	130	2.108	0.140
Left lower leg	130	1.630	0.200
Right lower leg	130	3.012	0.080
Right foot	130	1.306	0.250
Left foot	130	2.959	0.080

*Difference;(p<0.05) statistical test; Kruskal Wallis

Table 6: Differences between MSD with elements of home environment (Has own room or private place)

Variable	Frequency (n)	x^2	p- value (p)
Neck	130	0.046	0.830
Right shoulder	130	1.026	0.310
Left shoulder	130	2.608	0.100
Upper back	130	1.135	0.280
Right upper arm	130	2.617	0.100
Left upper arm	130	2.314	0.120
Lower back	130	0.188	0.660
Right forearm	130	0.957	0.320
Left forearm	130	0.047	0.820
Right wrist	130	0.641	0.420
Left wrist	130	0.073	0.780
Hip/ buttock	130	0.285	0.590
Right thigh	130	1.162	0.280
Left thigh	130	0.804	0.370
Right knee	130	1.387	0.230
Left knee	130	0.024	0.360
Left lower leg	130	0.182	0.670
Right lower leg	130	0.029	0.860
Right foot	130	1.224	0.260
Left foot	130	0.959	0.320

*Difference;(p<0.05) statistical test; Kruskal Wallis

4. DISCUSSION

Prevalence of MSD among health sciences students

Based on the result obtained, this study found that there was a higher number of MSD among the health sciences student in Malaysia, especially in the neck region. This finding is also supported by other previous studies that investigated a similar study (Smith & Leggat, 2004; Alshagga et al., 2013; Smith et al., 2014; Abledu & Offei, 2015; James et al., 2018; Wami et al., 2020 Karinganda & Sony., 2021). A previous study reported that the neck (28.0%) was predominance and followed by the lower back (23.6%), wrist/hands (22.9 %,) and upper back (27.4 %) (Abledu & Offei, 2015). Another study revealed the common site of MSD neck (39.4%), followed by the lower back (34.0%), shoulders (30.9%), and upper back (35.1 %) (Tantawy et al., 2017).

The level of stress among health sciences students

In this study, it was revealed that 57.7% of participants had mild stress. Then, 41.5% of participants have moderate stress, and 0.8% have severe stress. It was similar to the previous study when 52.6% of participants had low-stress levels, 45.1% had moderate stress levels, and 2.3% experienced severe levels of stress (Sawai et al., 2022). However, the result was contradicted by the previous study when no students were there in the category of no stress and severe level of stress. Still, in this study, 0.8% of participants have a severe level of stress (Shetty et al., 2022).

Differences between MSD and elements of the home environment

This study has proved that there is a significant difference between MSDs in certain body regions which are the left upper arm, lower back, right forearm, left wrist, hip/ buttock, right and left foot and the element of the home environment which is "good lighting during daytime" which refers "natural light from the sun" among health sciences students in Malaysia. According to Ekpenyong et al., (2013), unfavorable aspects of the learning environment such as poor lighting, stifling heat, and noise can also raise the possibility of accidents and the subsequent emergence of musculoskeletal disorders (MSDs).

Other than that, this study has proved there is a significant difference between MSDs in certain body regions which are left shoulder and left upper arm and the element of the home environment which is "static chair and/ or static table" among health sciences students in Malaysia. The results were supported by Shohel Parvez et al. (2022) that students were prone to have MSD problems due to inappropriate furniture. Therefore, it is necessary to alter the design of the academic furniture to prevent or minimize MSD issues. Other than that, proper designing of chairs can increase efficiency, promote education quality that leads to correct posture in students, and reduces the risk of musculoskeletal disorders (Ansari et al., 2018).

Moreover, this study also revealed there is a non-significant difference between MSD in body regions and an element of a home environment, having an own room or private place. This finding was supported by the previous study when the living environment may also be a factor in inducing the stress in which the place may be noisy or lack equipment for studying (Mankus et al., 2015).

5. CONCLUSION

In conclusion, a high prevalence of MSD among health sciences students was revealed in this study, with pain in the neck being the most common body region affected. Next, more than half of the participants has mild stress ~~and~~ followed by moderate stress and severe stress. There were non-significant differences between MSD's overall body regions and elements of the home environment, which has their room or private place. However, there was a significant difference between MSD over certain body regions with the element of the home environment, which uses the static chair and/ or static table and has good lighting during daytime. The findings of this study give clear information about prevalence of MSDs among health sciences student. Hence,

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RESEARCH ARTICLE

Awareness and knowledge of diagnostic reference levels in computed tomography among radiographers in public and private hospitals in Selangor

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Abstract:

Diagnostic Reference Level (DRL) is an efficient tool for optimising patient protection in medical exposures during diagnostic and interventional procedures without jeopardising the diagnostic information in the image. DRLs have limited value without awareness and knowledge. The purpose of this study was to determine awareness and knowledge of DRL in CT among radiographers in public and private hospitals in Selangor. An online questionnaire survey was administered to radiographers (n=98) in the selected seven public and seven private hospitals in Selangor via social media platforms. The study demonstrated that radiographers working in the private hospitals (61.2%) had high level of awareness than those working in public hospitals (32.7%). Additionally, it was discovered that public hospital radiographers (63.3%) had a higher degree of knowledge than private hospital radiographers (36.7%). Although most of the radiographers have a good level of awareness and knowledge of DRL in CT, enhanced training and re-training should be performed to improve the current practice and update the radiographer's knowledge of the current issues and topics on dose optimization in CT. This two-tier health care system should work as a team when involving with patients' safety to provide a good service to the community.

Keywords: awareness, computed tomography, diagnostic reference level, knowledge, radiographer

1. INTRODUCTION

Computed Tomography (CT) is recognized as a modality with a high radiation dose, with the concern that the doses given may be clinically unjustified in some cases (Holmberg et al., 2010). The introduction of multidetector array technology and the development of advanced protocols has broadened the variety of possible applications, resulting in a large growth in CT usage (Tonkopi et al., 2017). Because of the potential hazards of ionizing radiation and the importance of patient safety, the rising demand for CT examinations has become a serious concern.

Diagnostic Reference Level (DRL) was introduced in 1996 in Publication 73 by the International Commission on Radiological Protection (ICRP). To identify unusually high dose levels, DRLs should be used as a type of investigation level. When DRLs are consistently exceeded, a local review is usually conducted. DRLs are not intended for regulatory or commercial purposes, and they do not represent a dose constraint. They are also not linked to limits or constraints (Paulo et al., 2020). DRL is an effective tool that helps in optimisation of protection in medical exposures in diagnostic and interventional procedures for patients without jeopardising the diagnostic information in the image (Vañó et al., 2017). Malaysia has established a guideline on DRL in 2013 which contains various types of modalities such as general x-ray, fluoroscopy, CT scan, and mammography but only limited to the adult population and there are no recent updates on this guideline. Due to the vary of equipment and procedure protocols between facilities in countries or regions, the establishment of national or regional DRL is considered as good practice (Vassileva & Rehani, 2015).

Knowledge and awareness of the radiographers regarding dose optimisation will help in achieving good image quality to help in diagnostic with an optimisation dose given to the patient. Without awareness and knowledge, DRLs themselves have only limited value. Few studies had shown that radiographers have limited knowledge regarding CT doses optimisation (Karim et al., 2016; Abdulkadir et al., 2021; Mahmoudi et al., 2019). Radiographers' practices and knowledge of DRLs are directly related to training and strength of preceptorship (Bawazeer, 2022) that might be

different according to the type of hospital which might influence the degree of radiographers' awareness and knowledge. However, there has been little research comparing the knowledge and awareness of DRLs in CT among public and private radiographers. Thus, the purpose of this study is to analyse the level of awareness and knowledge of diagnostic reference level (DRL) in CT among radiographers in public and private hospitals in Selangor, where radiology departments are vast and equipped with a variety of imaging modalities.

2. MATERIALS AND METHODS

2.1. Study population and design

This study included 98 English-speaking radiographers, 49 from public and private hospitals each in Selangor. Radiographers from teaching hospital are excluded.

The online survey/self-administered questionnaire was distributed for four months (April until July 2022) among radiographers working in public and private hospitals in Selangor via social media platform (e.g.: Whatsapp) and Malaysian Society of Radiographers facebook group. The online questionnaire, which was adapted and adopted from Abdulkadir et al., (2021), Hawarihewa et al., (2021) and Paolicchi et al., (2016), consists of three sections including sociodemographic data in section 1; awareness of essential general radiation protection and optimisation in CT in section 2; and knowledge and awareness about DRLs and their application as an optimisation tool in section 3. Correct answers for each question were given a score of 1, while incorrect or blank answers were given a score of 0. The score obtained for awareness questions were grouped into high level (5 - 6 score), middle level (3 – 4), and low-level (0 – 2 scores) and for knowledge questions, high level (7 - 9 score), middle level (4 – 6), and low-level (0 – 3 scores).

2.2. Validity and reliability

The questionnaire reliability was assessed in terms of consistency by using Cronbach's alpha (α) coefficient at a 95% confidence interval with a threshold for statistical significance set at $p < 0.05$. The resultant Cronbach's alpha is 0.714. A pilot study was carried out with 12 radiographers before actual data were collected and minor modifications were made based on the feedback received from the pilot study participants.

2.3. Ethical consideration

This study was approved by the Universiti Teknologi MARA (UiTM) research ethics committee (FERC/FSK/MR/2021/0055).

3. RESULTS

The sociodemographic characteristics of the radiographers are presented in Table 1. Most radiographers (69.4%) were females between the ages of 25 and 35 (61.2%), 69.4% were diploma holder and 41.8% have 5 to 10 years of working experiences.

Table 1. The sociodemographic data of the respondents

Characteristic	n	%
Gender		
Male	68	69.4
Female	30	30.6
Age		
< 25	24	24.5
25 – 35	60	61.2
36 – 45	14	14.3
46 – 55	0	0
>55	0	0
Type of Hospital		
Public Hospital	49	50.0
Private Hospital	49	50.0
Academic Qualification		
Diploma	68	69.4
Bachelor's degree	26	26.5
Master's degree	4	4.1
Doctoral degree		
Working Experience in CT		
No experience	15	15.3
< 5 years	38	38.8
5 - 10 years	41	41.8
10 - 15 years	4	4.1
15 – 20 years	0	0
>20 years	0	0

This study demonstrated that 48 and 38 radiographers from the private and public hospitals were aware about the dose display on the CT console, with 84.7% selecting a distinct scan procedure for adult and paediatric scans and 87.8% taking DRL into consideration to maximise patient protection. The radiographers' responses to awareness of DRL in CT is shown in Table 2.

Table 2. Radiographers' responses to awareness of DRL in CT

Yes		**No**	
n (%)		**n (%)**	
Public	**Private**	**Public**	**Private**
n=49	**n=49**	**n=49**	**n=49**
38 (77.6)	48 (98)	11 (22.4)	1 (2)
44 (89.8)	39 (79.6)	5 (10.2)	10 (20.4)
38 (77.6)	48 (98)	11 (22.4)	1(2)

In addition, most of the of radiographers (60.2%) and (81.6%) were aware on the types of patients who are most sensitive to ionising radiation and the types of tissues that are highly vulnerable to ionising radiation. When asked about the quantity used to express CT dose, 91.8% of respondents correctly responded that it consisted of 41 and 49 public and private radiographers, respectively. Additionally, 99% of respondents agreed that scan protocols are important for CT dose optimization. However, 61 of 98 radiographers get the notion of dose optimisation wrong. The radiographers' responses to knowledge of DRL in CT is shown in Table 3.

Table 3. Radiographers' responses to knowledge of DRL in CT

Correct n (%)		**Incorrect n (%)**	
Public n=49	**Private n=49**	**Public n=49**	**Private n=49**
25 (51)	34 (69.4)	24 (49)	15 (30.6)
42 (85.7)	38 (77.6)	7 (14.2)	11 (22.4)
25 (51)	12 (24.5)	24 (49)	37 (75.5)
41 (83.7)	49 (100)	8 (16.3)	0
48 (98)	49 (100)	1 (2)	0

This research also revealed that 48 and 35 radiographers of the public and private hospitals, respectively and 35 public radiographers claimed that they were aware of the DRL in CT. However, when asked if they had ever conducted a CT dose survey or engaged in an evaluation scan protocol as a result of the reported abnormal dose, only 56 and 40 radiographers had participated, respectively. The radiographers' responses to the awareness of DRL in CT is shown in Table 4.

Table 4. Radiographers' responses to the awareness of DRL in CT

Yes n (%)		**No n (%)**	
Public n=49	**Private n=49**	**Public n=49**	**Private n=49**
35 (71.4)	48 (98)	14 (28.6)	1 (2)
25 (51)	31 (63.3)	24 (49)	18 (36.7)
14 (28.6)	26 (53.1)	35 (71.4)	23 (46.9)

Furthermore, 60.2% of radiographers correctly answered the purposes of DRLs. Regarding the dosage quantities utilised for establishing DRLs in CT for $CTDI_{vol}$ and DLP, respectively, 91.8% and 88.8% of radiographers provided accurate responses. However, more than half of radiographers (54.1%) give the inaccurate response that Size Specific Dosage Estimates (SSDE) are not the dose amounts used to determine DRLs in CT as shown in Table 5.

Table 5. Radiographers' responses about knowledge of DRL and its application as an optimisation tool

Correct n (%)		**Incorrect n (%)**	
Public n=49	**Private n=49**	**Public n=49**	**Private n=49**
27 (55.1)	32 (65.3)	22 (44.9)	17 (34.7)
42 (85.7)	48 (98)	7 (14.3)	1 (2)
43 (87.8)	45 (91.8)	6 (12.2)	4 (8.2)
32 (65.3)	13 (26.5)	17 (34.7)	36 (73.5)

Moreover, this study revealed that 30 and 16 radiographers from private and public hospitals, respectively, displayed high levels of awareness, while middle level awareness of radiographers in public hospital (61.2%) and private hospital (36.7%) was discovered. Three public radiographers and one private radiographer indicates a low level of awareness.

As for the knowledge, only 18 private radiographers have high level of knowledge compared to 31 out of 49 public radiographers. There were 18 public radiographers and 31 private radiographer with middle or intermediate level knowledge and no radiographer has a limited amount of understanding. The level of awareness and knowledge is showed in Table 6.

Table 6. Frequency and percentage of level of awareness and knowledge based on type of hospital

	Awareness Level		
Hospitals	**High level n (%)**	**Middle level n (%)**	**Low level n (%)**
Public	16 (32.7)	30 (61.2)	3 (6.1)
Private	30 (61.2)	18 (36.7)	1 (2)
	Knowledge Level		
Public	31 (63.3)	18 (36.7)	0
Private	18 (36.7)	31 (63.3)	0

4. DISCUSSION

The national guideline on DRL has been established in Malaysia in 2013 and consist of various type of imaging modalities such as general x-ray, fluoroscopy, CT scan, and mammography that only focus on the adult population with no recent updates (*Malaysian Diagnostic Reference Levels in Medical Imaging (Radiology)*, 2013). The recommended DRLs are reported to efficiently reduce the radiation dose to the patient (Brenner et al., 2001). Consequently, radiographers' knowledge should be strengthened with continuous education about the importance of utilizing DRLs as their knowledge will reflect on their scanning performance.

4.1 Awareness and knowledge about essential general radiation protection and optimisation in CT

In this study, the general knowledge regarding the general radiation protection and optimisation in CT shows that most of the radiographers who account for more than half of the participants answered most of the questions correctly. However, when asked about the concept of dose optimization, 62.2% (61 out of 98) participants answered it incorrectly that might be due to the inclusion of this theoretical definition of dose optimization in most of the educational and training courses. In addition, radiographers had shown good practical experience concerning the protection optimization as most of them were aware of the dose display on the CT console and select different scan protocols between adults and children.

Existing studies have demonstrated fluctuations in the awareness and knowledge of radiation protection and dose optimization. Some of the studies reported good knowledge (Hawarihewa et al., 2021; Rawashdeh et al., 2018; Almohiy et al., 2020) while others reported poor knowledge (Abdulkadir et al., 2021; Zekioğlu & Parlar, 2021; Alhasan et al., 2016; Portelli et al., 2016) about the radiation protection of CT parameters. This might be due to the difference in education courses or level of qualifications and training that different between each institute and country.

4.2 Knowledge and awareness about DRLs and its application as an optimisation tool

This section demonstrated that a large proportion of the radiographers 84.7% (83 of 98) declare awareness of DRL in CT but cannot describe the function of DRLs. Besides that, around more than half of the participants do not choose SSDE as the suitable dose quantity for establishing DRLs. SSDE is not a direct dose quantity that mostly used for setting the pediatric DRLs as the dose are predominantly depends on the body size. Thus, this might the factor why the majority of radiographers does not familiar with the dose quantity.

The previous survey-based studies show that most radiology personnel (radiographers, radiologists, CT technologists) declare awareness of the DRL (Mahmoudi et al., 2019; Abdulkadir et al., 2021; Hawarihewa et al., 2021). Despite their awareness, it is found that the knowledge regarding CT DRLs was lacking. It is stated that a low level of knowledge of CT DRLs may be caused by a lack of local and national DRLs and proper training for the radiology personnel (Mahmoudi et al., 2019).

The normalized nature of CT data will always make the image appears properly exposed, unlike traditional radiographic imaging. Thus, the radiographer should be aware of the DRLs and optimise the protocols to prevent the patient's overexposure. DRLs can help reduce patient dose from CT examinations after the scanning protocol has been changed or improved following a review (Tonkopi et al., 2017). As a result, DRLs have proven to be a useful tool in optimising CT practice over the years and should be repeated periodically (Vañó et al., 2017; Ogbole & Obed, 2014). Hence, cooperation from the medical physicist and radiologist together with the radiographers' knowledge and skills regarding strategies for reducing the dose received by patients is essential (Tsapaki, 2020; Bwanga & Chanda, 2020).

4.3 Level of awareness and knowledge between radiographers of publics and private hospitals.

In this study, radiographers' level of awareness and knowledge regarding DRL in CT shows a significant difference between the public and private radiographers. Lack of ionising radiation and safety training is one of the factor that cause the discrepancy in awareness and knowledge between public and private radiographers. It has been demonstrated that monthly or annual ionising radiation and safety training improves radiographers' awareness and knowledge (Rawashded et al., 2018; Farajollahi et al., 2014). However, the organization or funding of the courses has a significant impact. According to the study by Evripiotis et al. (2013), the majority of radiographers who participate in extensive training acknowledge the support of their hospital's management in the planning of the training programme.

In Malaysia, continuing medical education (CME) is necessary annually for licence renewal and is mostly funded by the institution and healthcare technology businesses, which explains for the zero or no respondents who indicated that their level of knowledge was low.

Several limitations were identified in this study. The variables in this study were based on self-reports rather than on objective assessment, potentially causing bias and only included radiographers who are working in Selangor state which may not a representative of the entire population of CT radiographers in Malaysia. Furthermore, this study also only focuses on the basic DRLs knowledge without any targeted examination (e.g CT abdomen) or type of patient (e.g pediatric).

5. CONCLUSION

This study strives for a better CT practice through the emphasis on the DRLs among the radiographers in the public and private hospitals in Selangor. The radiographers from both public and private hospitals exhibited good knowledge regarding radiation protection and dose optimization.

As a recommendation, assessment of radiographer's skill objectively could be done to see their competency and adherence level before doing any intervention program. Training and re-training programs among the radiographers should be implemented to improve the current practice and update their knowledge of the current issues and topics on dose optimization in CT. This two-tier health care system should work as a team when involving with patients' safety to provide a good service to the community. Besides that, undergraduates also should be trained to increase their level of awareness and knowledge regarding DRL. Hence, this will reduce the patient dose received according to the ALARA principle of radiation protection.

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REVIEW ARTICLE

A mini review on the methods for the extraction, isolation, and determination of *P. odorata*'s bioactive compounds

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Abstract:

Persicaria odorata is a perennial herb of the *Persicaria genus,* which belongs to the *Polygonaceae family.P. odorata* is commonly known in Malaysia as *daun kesum* and is widely used in cuisine and has different medicinal benefits. The medicinal benefits from *P. odorata* are contributed by its various bioactive compounds and biological activities. Thus, phytochemical analysis has been researched extensively to maximize the benefits of the plant. For herbal studies, extraction plays a crucial step in extracting the preferred bioactive compounds hence several extraction techniques such as chromatography, electrophoresis, and spectroscopy have been developed to separate and identify bioactive compounds. In turn, these compounds play a big role on the biological activities of the plant. This review highlights the methods for extraction, separation, and identification of bioactive compounds and the biological activities of *P. odorata.*

Keywords: Bioactive compounds, Biological activities, Extraction method, Isolation, *Persicaria odorata*.

1. INTRODUCTION

*P. odorata (*Lour.*)* Soja'k has been reclassified from *Polygonum odoratum* Lour. (Starkenmann et al., 2006). *P. odorata* is a perennial herb that owns to the family *Polygonaceae* and the genus of *Persicaria* (Ridzuan et al., 2013). *P. odorata* is part of a fresh herb group called cilantro and imitates the 'cilantro' flavor. In Brunei, Singapore, and Malaysia, it is called *daun kesom* and is widely used in food preparations as a flavoring material. *P. odorata* is a tender perennial herb with a height of 30-35 cm and 6-15cm of pointed leaves with a conspicuous dark purple sign in the middle of the leaves, which are green, lanceolate, and reed stems. This herb has a pungent and spicy taste and an odour like coriander with a lemon scent hint. This unique strong smell is reported due to the presence of decanal, undecanal, dodecanal, (Z)-3-hexen-1-ol, and (Z)-3-hexanal (Starkenmann et al., 2006).

In plants and fruits, many antioxidants are found: phenolics, carotenoids, anthocyanins, and tocopherols. In pharmaceutical trials, 20% of recognized plants have been used, impacting the health care system in beneficial ways, such as treating cancer and other diseases (Altemimi et al., 2017). Plants that contain beneficial phytochemicals can act as natural antioxidants, supplements that the human body needs. There are several elements involved in phytochemical plant research: compound extraction from a plant, isolation of the substances to be analyzed, recognition and analysis of the substances extracted, inspection of the biosynthetic mechanisms of a particular molecule, and quantitative evaluation.

Complementary and alternative medicine (CAM) has become more essential in treatment because it is secure, organic, and efficient in treating diseases. In general hospitals, CAM has been commonly used to resolve medical issues such as infections and complications and protect patients' health (Ridzuan et al., 2013). The leaves of *P. odorata* have been used as a traditional medicine to treat various ailments such as diarrhoea and inflammation. Aside from human ailments, *P. odorata* has the potential to cure zoonotic diseases like mastitis (Hashemi et al., 2008). They contain a wide range of bioactivities, including antioxidant, antifungal, antibacterial, and anti-inflammatory properties, owing to the presence of significant volatile compounds such as long-chain aldehydes and other secondary metabolites of plants (phenolic compounds and flavonoids) (Sim et al., 2019). Earlier research has found that *P. odorata* has a spectrum of therapeutic activities, and a few are highly useful, like antioxidant, anticancer, antibacterial, and anti-inflammatory. Using the herb in food is also a great idea as it may preserve or strengthen biological functions and decrease the incidence of illness. The association of plant extract with traditional antibiotics has not yet been recognized (Ridzuan et al., 2017).

Many extraction methods are used to obtain bioactive compounds from plant products, including distillation, solvent extraction, sublimation, and pressing. This review aims to demonstrate the process of extracting, isolating, and

identifying *P. odorata* for its bioactive compounds and biological activities.

2. DISCUSSION

2.1. Bioactive Compounds/Phytochemicals

Chemotherapeutic employments of the medicinal plant are simply the ancient proof of humankind (Alam et al., 2017). Initially, humans used herbs for their cooking only. Still, with the disclosure of therapeutic potential, this daily herb has become a valuable root of illness fixation and well-being in different human societies (Vinatoru, 2001). The ancient history of bioactive compounds is using medicinal plants in old age. In the past, individuals did not know about bioactive compounds. However, utilization of these molecules was adequately assorted in various possibilities.

Organic compounds produced by the plant can be categorized as primary or secondary metabolites. The primary metabolites include phytosterols, carbohydrates, proteins, organic acids, and lipids, are chemical elements essential for metabolic cellular respiration and sustaining life through photometric synthesis, enhancement, and development. At the same time, secondary metabolites have various chemical structures able to produce biological effects on human health (Alam et al., 2017). According to Martin & Demain (1978), specialized metabolites are those compounds that are typically developed in the post-growth process, do not have a growth function (even though it could have a reliability function role), make by taxonomic classes of microorganisms, have peculiar chemical composition, and sometimes produced as combinations of strongly linked natural compound members. Bioactive plant compounds are usually manufactured as secondary metabolites. Any of these compounds within the secondary metabolites affect biological processes considered to be bioactive. Hence, specialized metabolites that cause pharmacological or toxicological impacts in humans and wildlife are a simple definition of plant bioactive compounds (Bernhoft, 2010).

Six key groups of phytochemicals have been categorized based on their chemical compositions and characteristics: carbohydrates, alkaloids, lipids, terpenoids, phenolics, alkaloids, and other substances, including nitrogen. Under research, it is possible to distinguish phytochemicals into major groups, such as polyphenols and carotenoids, including flavonoids, stilbenes/lignans, and phenolic acids. Based on their similar chemical composition, flavonoids can be further classified, such as flavones, flavanols, isoflavones, flavanones, and anthocyanins (Huang et al., 2015).

2.2. Method Uses for Extraction, Isolation, and Identification of Bioactive Compounds

The beginning step for the study of herbal plants is extraction and one of the critical steps since it is mandatory to bring out the preferred composition for later isolation and detection. Primary extraction procedures like pre-washing, drying of plant materials or freeze-drying and grinding maximize analytical extraction kinetics and improve the interface surface of the sample with the solvent (Sasidharan et al., 2011). In varying circumstances, multiple extraction techniques can be used to consider the selectivity of extraction from different natural sources. Various solvents with varying polarities must be applied to get numerous phenolic compounds from plants with high precision (Wong et al., 2006). Polar solvents like ethyl-acetate, methanol and ethanol are being used to extract the hydrophilic substances. Meanwhile, the solvents used for lipophilic compound extraction are dichloromethane or a 1:1 mixture of dichloromethane and methanol.

Digestion, percolation, infusion, maceration, and boiling under reflux are typical extraction methods. These methods are the easiest extraction method, but it takes a long time. Rapid solvent extraction, steam distillation, supercritical fluid extraction, sonication (ultrasound-assisted extraction), microwave distillation, and hydrodistillation were done to evade flaws in the traditional extraction technique, which is the modern extraction method (Zhang et al., 2018). The conventional extract techniques are maceration, soxhlet extraction, and hydrodistillation. While microwave-assisted extraction, pressurized liquid extraction, supercritical fluid extraction, enzyme-assisted extraction, pulsed electric field-assisted extraction, and ultrasound-assisted extraction is the non-conventional extraction technique.

The detection and isolation of plant bioactive compounds is a method that has been redeveloped in recent years (Altemimi et al., 2017). The objective of observing bioactive compounds is to search for a proper approach to classify biological activity, such as antibacterial, cytotoxicity, or antioxidant, combined with simplification, precision, and rate (Mulinacci et al., 2004). Plants extracts usually have a combination of various phytochemicals with different polarities. The steps of identification and characterization of the bioactive compound remain a big challenge. Dissimilar isolation methods, like High-performance liquid chromatography (HPLC), thin-layer chromatography (TLC), sephadex chromatography, flash chromatography, and column chromatography must use as standard procedures in the isolation of these bioactive compounds to isolate pure bioactive compounds. Other than that, non-chromatographic methods like immunoassay using fourier-transform infrared spectroscopy (FTIR), phytochemical screening assay, and monoclonal antibodies (MAbs) can be utilized to achieve and promote the detection of bioactive compounds (Sasidharan et al., 2011).

2.3. Extraction, Isolation, and Identification Method of Bioactive Compounds from *P. odorata*

Extraction for GC profile, the *P. odorata* leaves been minced will cover with dichloromethane. Then the mixture stood overnight, dried with Na_2SO_4 and inserted into a GC-MS on a polar and an apolar column. Using GC-MS-O, undecanal, (Z)-3-hexanol, (Z)-3-hexanal, dodecanal, and decanal which are the organic compound, were discovered.

Other than that, 3-sulfanyl-hexan-1-ol, 3-sulfanyl-hexanal, and aldehydes were uncovered (Starkenmann et al., 2006). Sasongko et al. (2011b) reported the volatile compound that was extracted by three solvents (petroleum ether, acetone, and ethanol) and the yield extract each solvent was 0.90, 6.33, and 4.49%. The result showed that the main volatile compound extracted by ethanol was ocimene (26.44%); acetone and petroleum ether extraction was dodecanal, with a relative peak area at 27.14% and 53.12%. Decanal, dodecanal, beta-caryophyllene, neophytadiene, and ethyl hexadecanoate are the other volatile compounds extracted by these three solvents (Sasongko et al., 2011b).

Ridzuan et al. (2014;2017) studies showed that the major volatile compounds in the n-hexane extract revealed by the GSMS analysis were β-citral, decanal, α-citral, caryophyllene, drimenol, dodecanal, euparone, drimenol, Z-citral, 2,4-heptadiene,2,6 dimethyl, and alkene (Ridzuan et al., 2013; Ridzuan et al., 2017). Ahongshangbam et al. (2014) revealed that ferulic acid, apigenin, quercetin, gallic acid, p-coumaric acid, and ellagic acid were the bioactive compounds that have been identified thru high-performance liquid chromatography analysis. They extracted the dried *P. odorata* with 100ml of ethanol and then the whole extract was extracted three times with ethyl acetate (Ahongshangbam et al., 2014). Saad et al. (2014) extract *P. odorata* using three different techniques, which are maceration, percolation and decoction, to determine which extract gives the most effective antimicrobial activity. The results show that the extract percolation and maceration techniques were more effective because the solubility of the active components is influenced by the type of solvent used in the extraction technique (Saad et al., 2014).

P. odorata were extracted with a methanol/water mixture (1:1, v/v) using an ultrasonic bath at room temperature thrice (3x15 min). High-performance liquid chromatography coupled with diode-array detection and electrospray ionization tandem mass spectrometry (HPLC-DAD-MSn) method was used to analyze the methanolic-aqueous extracts and kaempferol sulphate, quercetin 3-O-β-D-glucuronide, methyl gallate, (+)-catechin, and tetrahydroxyflavonol derivative are the bioactive compounds that been identified (Pawłowska et al., 2020). Yanpirat & Vajroda (2015) reported the chemical constituent from the lipophilic extract. The results obtained from the TLC technique were terpenoids, steroids, and other unidentified organic compounds but not alkaloids (Zhang et al., 2018). Table 1 summarises the method used and the list of bioactive compounds identified from leaves extract of *P. odorata.*

Table 1: Method used and the list of bioactive compounds identified from leaves extract of *P. odorata.*

Method for extractions	Method for isolation and identification	Bioactive compounds	References
Leaves extracted with n-hexane (n-hex), dichloromethane (DCM), Methanol (MeOH) and water.	Gas Chromatography Mass Spectrometer (GCMS)	Major volatile compounds: Decanal, β-citral, α-citral, dodecanal, caryophyllene, euparone, drimenol, Z-citral, 2,4-Heptadiene,2,6-Dimethyl, and alkene.	Ridzuan et al. (2017) Ridzuan et al. (2014)
Ethanolic extract	High-performance liquid chromatography	Apigenin, gallic acid, quercetin, p-coumaric acid, ferulic acid, and ellagic acid	Ahongshangbam et al. (2014)
Hydrodistillation uses to extract the essential oil from the fresh and dry leaves *of Persicaria odorata.*	Gas Chromatography-Mass Spectrometry (GC-MS analysis)	Caryophyllene, dodecanal, decanal, drimenol, and alpha-caryophyllene	Sasongko et al. (2011a)
Hydrophilic extract and lipophilic extract with distilled water and chloroform.	Thin-layer chromatography (TLC)	Terpenoids, steroids, and other unidentified organic compounds but not alkaloids.	Yanpirat & Vajrodaya (2015)
P. odorata was extracted with three types of solvents ethanol, 50% ethanol and aqueous extract.	Preparative HPLC	Quercitrin and scutellarein-7-glucoside.	Okonogi et al. (2016)
Essential oils obtained by hydrodistillation	Gas chromatography with flame ionization detector (GC–FID) and gas chromatography coupled to mass spectrometry (GC–MS)	N-dodecanal (37.1%), n-decanal (18.1%), 1-decanol (5.4%), 1-dodecanol (4.8%), α-humulene (4.5%), cis-caryophyllene (3.9%) and n-undecane (2.5%).	Rebícková et al. (2020)

Extracted with 99.9% of methanol by ultrasonification	Phytochemical element test	Sulphate, Nitrate, Tanins & Phenols	Saad et al. (2015)
Methanolic-aqueous extracts	HPLC-DAD-MSn validated analytical method	Methanolic-aqueous extracts, kaempferol sulfate, Quercetin 3-O-β-D-glucuronide, methyl gallate, (+)-catechin, and tetrahydroxyflavonol derivative	Pawłowska et al. (2020)
Macerated with methanol solvent then followed by Soxhlet extraction	Phytochemicals analysis is performed by using standard qualitative methods	Saponins, tannins, total phenols, flavonoids, and alkaloids	Sim et al. (2019)
P. odorata extract by three solvents, petroleum ether, acetone and ethanol	GC-MS analysis.	Caryophyllene, dodecanal, beta-pinene, ocimene, neophytadiene, and ethyl hexadecanoate	Sasongko et al. (2011b)

2.4. Biological Activities

2.4.1. Microbial activity

The ability for antibacterial, antioxidant, antifungal, anti-inflammatory, anti-diarrheal, anti-cytotoxic, anti-ulcer, and antigen-toxicity activities of *P. minor* has been identified (Qader et al., 2011; Uyub et al., 2010; Wasman et al., 2010). Few studies have stated that because of terpenes and aldehydes such as decanal, dodecanal, eremophillene, alpha-curcumene, and caryophyllene. *P. odorata* has antimicrobial properties as the significant essential oil compounds present in leaves (Abu Bakar et al., 2015; Sasongko et al., 2011a)

Abu Bakar et al. (2015) studied the antibacterial activity of *P. odorat*a leaf material by using two types of solvent extractions which are 30% aqueous-ethanol and 100% aqueous solvents. *P. aeruginosa, S. aureus, E. coli, and E. faecalis* were utilized for the antibacterial assessment of *P. odorata* extracts. To get the active strains accordingly, each test organism's culture stock was sub-cultured at 37 °C for 24 hours on fresh nutrient agar plates. Kirby-Bauer disk diffusion was implemented for antibacterial activity screening of plant extracts, and the results indicate that both extracts of *P. odorata* show strong activity against certain pathogenic bacterial strains. The sensitivity of aqueous extracts and crude aqueous ethanol was tested using the disc diffusion method at four different concentrations, which are 25 mg/ml, 50 mg/ml, 100 mg/ml, and 200 mg/mL DMSO. The result revealed that *S. aureus, E. faecalis, and E. coli* were susceptible to both extracts. Nevertheless, E. faecalis did not demonstrate any action at a concentration of 25 mg for aqueous-ethanol extract. *S. aureus* and *E. coli* were the most susceptible species to aqueous-ethanol extraction, followed by *E. faecalis*. For the aqueous extract, all bacteria were sensitive at all concentrations except at 25 mg all three bacteria did not show the inhibition zones. The inhibition zones for *E. faecalis, S. aureus,* and *E. coli* were highest when using the highest extract concentration. For aqueous-ethanol extract, the inhibition zone with a diameter of 19.33mm, 19.50 mm and 18.00 mm, while for aqueous extract 15.70 mm, 16.60 mm, and 16.45 mm. But for the *P. aeruginosa*, it not susceptible to all concentrations of both extracts may because of gram-negative bacteria so it may be affected by the density of its membrane surface. The usage of low dosage or solvent during extraction also can be one of the reasons why *P. aeruginosa* does not sensitive to both extracts (Abu Bakar et al., 2015).

Various kinds of extractions have used to evaluate the antimicrobial activity of the most active plant extract (Ridzuan et al., 2013; Saad et al., 2014). To get the particular extract, *P. odorata* was extracted using the following extracts: n- hexane, dichloromethane, Methanol and water. Eight bacterial strains which included gram-positive bacteria (*S. epidermidis, S. aureus, S. pneumoniae,* and *S. pyogenes*) and gram-negative bacteria (*K. pneumoniae, P. aeruginosa, S. typhi,* and *E. coli)* were tested against all extracts with four different concentrations (400, 200, 100 and 50 mg/ml)(Ridzuan et al., 2013). While Saad et al. (2014) extract the *P. odorata* leaves by using maceration assisted by ultra-sonication, percolation with soxhlet extractor, and decoction and extracts with three various concentrations (100mg/ml, 75mg/ml, and 50mg/ml) being tested against four bacterial strains which are *E. coli, S. aureus, B. subtilis,* and *Salmonella spp* (Saad et al., 2014). To determine and screen the antimicrobial activity disc diffusion method was used (Ridzuan et al., 2013; Saad et al., 2014). *S. aureus, S. epidermidis, S. pneumoniae,* and *S. pyogenes* were the bacterial strains that susceptible to n-hexane extract. The bacteria with the most susceptibility for DCM extraction were *S. epidermidis, S. aureus, S. typhi*, and *S. pyogenes*, but *S. typhi* was only vulnerable at 400 mg/ml concentration of DCM extract. Then, only two bacteria were efficient against the methanol extract, which is *S. epidermidis* and *S. aureus.* Lastly, for the aqueous extract, the inhibition zones were observed on *S. aureus* (10.00±2.00mm), *S. pneumoniae* (16.00±2.00mm), and *S. pyogenes (*14.33±1.52mm*)* (Ridzuan

et al., 2013). Antimicrobial activity only shows on *E. coli* and *S. aureus* for the extract obtained from decoction with a zone of inhibition of 6mm at 100mg/ml concentration. Meanwhile, the extraction obtained from ultra-sonic maceration and percolation using a soxhlet extractor showed antimicrobial activity against *B. subtilis, S. aureus, E. coli,* and *Salmonella spp* with rising inhibition zone along with extract concentration. The antimicrobial test showed that extract from maceration and percolation technique are more successful than decoction technique because the solubility of bioactive compound of the leaves are affected by the type of solvent being used in extraction (Saad et al., 2014).

Antibacterial activity against Gram-negative bacteria such as *E. coli* and gram-positive bacteria such as *S. aureus* shows strong activity by using the essential oil extracted from the fresh and dry leaves of *P. odorata*. The average zone of inhibition (ZOI) produced by essential oil from fresh and dry leave against *S. aureus* were 21 and 26 mm, while the average against *E. coli* was 13 and 19mm. As essential oil performs better against gram-positive bacteria than against gram-negative bacteria, *E. coli* has a lower average inhibition zone than *S. aureus* (Sasongko et al., 2011a). Antimicrobial activity of *P. odorata* essential oil shows the various range, 1024 $\mu g \cdot mL^{-1}$, 512–1024 $\mu g \cdot mL^{-1}$ in agar and 128–1024 $\mu g \cdot mL^{-1}$, 512–1024 $\mu g \cdot mL^{-1}$ in broth. *P. odorata* showed the lowest Minimum inhibitory concentration against *E. faecalis, B. subtilis,* and *S. pyogenes* which is 512 $\mu g \cdot mL^{-1}$ in the liquid stage. While for the vapor stage, the lowest Minimum inhibitory concentration that being detected against *E. coli* is 512 $\mu g \cdot mL^{-1}$. Essential oils are more sensitive to tested with gram-positive compared with gram-negative bacteria because essential oils have active compounds that can effectively separate the essential bonds in the cell wall of gram-positive bacteria (Řebíčková et al., 2020).

2.4.2. Antifungal activity

The bioautography method, thin layer chromatography, was used to investigate the inhibitory activities of lipophilic extract from *P. odorata* against *Colletotrichum capsici and Colletotrichum gloeosporioides*. From the bioautography and microdilution bioassay, the results showed that the lipophilic extract of *P. odorata* showed more capable to inhibit spores of *C. gloeosporioides* compared to *C. capsici*. This is being shown by clear zones showing the inhibition of the fungus that can be detected for *C. gloeosporioides* but not for *C. capsica* (Yanpirat & Vajrodaya, 2015).

In a study carried out by Chan et al. (2018), extractions of the fresh leaves produced significant antifungal activities in two of its extracts, such as hexane and chloroform, which showed broad-spectrum fungicidal activity (Chan et al., 2018). The antifungal activities were done using hexane, dichloromethane, methanol, and water extracts against *Candida albicans* and the result proved that none of the extracts was active against *C. albicans* (Ridzuan et al., 2013). Other research used oven-dried leaves, so the bioactive compounds in the plant may reduce or degrade during drying (Chan et al., 2018).

2.4.3. Anti-inflammatory effect

In the ethanol extract of *P. odorata,* it was found that quercetin and scutellarein-7-glucoside are the main compounds for the anti-inflammatory effect. By decreasing IL-6-secretion, it shows that scutellarein-7-glucoside and quercitrin give about 50% of the anti-inflammatory effect of *P. odorata* (Okonogi et al., 2016). In the methanol extract of *P. odoratum*, two major compounds, 3, 7, 11, 15-tetramethyl-2-hexadecen-1-ol and E-15-heptade-cenal, may be found associated with their anti-inflammatory effects. By hindering the production of nitric oxide in a concentration-dependent manner (IC50 = 53.75+0.72 μg/mL), the DLE displayed a potent anti-inflammatory effect (Chansiw et al., 2019). The anti-inflammatory activity of *P. odorata* compounds can be used as an alternative or complementary treatment.

2.4.4. Antioxidant activity and anticancer properties

P. odorata has antioxidant properties that can prevent or delay our body from suffering from oxidative damage, and the properties are a substance or nutrients in our food. Oxidation of other molecules is inhibited, which means that electrons or hydrogen are moved to an oxidizing agent from a material. Since free radicals are generated because of these oxidation reactions, in our body cells, these radicals can trigger chain responses that can cause cell damage or death (Khaki & Fathiazad, 2012). Natural antioxidants can be found mainly in plants with rich phenolic compounds. 1,1-Diphenyl-2-picryl hydrazyl (DPPH) assay has been used to investigate the antioxidant activity of the *P. odorata* and the prominent IC50 value is 190.19±0.42 μg/ml.

The existence of polyphenols such as gallic acid, quercetin, ferulic acid, and apigenin are maybe the causes of the *P. odorata* prominent antioxidant effect. The ethanolic extract of the *P.odoratum* exhibited the ability to quench DPPH radical results showed that it provides a good antioxidant with free radical scavenging activity (Ahongshangbam et al., 2014).

P. odorata also has anti-cancer properties, and Mohamaed et al. (2006) has shown that homoisoflavone molecules from *P. odorata* generate apoptosis and detain G2/M cell cycles by modulating Bcl-2 protein in breast cancer cells. In several cell cancers, Bcl-2 is an anti-apoptotic enzyme that is over-expressed. Therefore, one of the methods to minimize cancer progression is the activation of Bcl-2 phosphorylation by the homoisoflavone enzyme (Rafi & Vastano, 2007).

3. CONCLUSION

Various techniques and solvents can extract the medicinal plants for their phytochemicals. Different solvents used in extractions will exhibit different types of bioactive compounds. Different extraction techniques also influence antimicrobial activity because the technique or solvent used

for extraction will affect the quality of the compounds from the leaves. From this review, the methods used for isolation and identification are High-Performance Liquid Chromatography (HPLC) and Gas Chromatography-Mass Spectrometry (GS-MS). As discussed above, bioactive compounds of *P. odorata* have biological activities antifungal activity, antimicrobial activity, anti-inflammatory effect, and antioxidant activity. It concludes that *P. odorata* is important to emerging as a potential green medicine and it is recommended for future research to use a more in-depth method to determine the mode of action of each bioactive compounds for further understanding.

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RESEARCH ARTICLE

Application of Calcium Phosphate as Remineralizing Agent in Oral Healthcare: A Bibliometric and Scientometric Analysis

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Abstract:

There has been increased interest in developing bioactive agents based on calcium phosphate (CaP) in oral care for enhancing enamel and dentin remineralization. This bibliometric and scientometric analysis explores the interdisciplinary view of calcium phosphates-based for alternative oral care concepts in preventive dentistry. Bibliometric analyses were performed using VOSviewer software taking SCOPUS as the main database for literatures retrieval. The analysis revealed highest number of CaP-related articles were published within 10 years that provide insights into the past and recent trends in the applications of CaP in oral care. Further, top three countries with the highest number of publications includes, the United States (n=58), China (n=50) and India (n=23). Finally, present study provides data on literatures, countries and authors that have been involved in CaP research extensively for the past years. Also, this study will help researchers, academicians and students to find suitable article for their referral in terms of the use of CaP as a biomaterial in dentistry.

Keywords: bibliometric, calcium phosphate, scientometric, tooth remineralization

1. INTRODUCTION

Dental caries or tooth decay is a highly prevalence oral infectious disease. Increased caries incidence has been one of the most common health problems and economic burdens globally (Bowen et al., 2018; Peres et al., 2019; Yin et al., 2017). In oral cavity, enamel is the outermost layer and hard mineralised surface of teeth that primarily contains crystalline calcium phosphate. Enamel is typically exposed to acidic environment which disrupt the balance of the tooth enamel remineralization/demineralization processes that could result in localized destruction of hard dental tissues and formation of cavities (Arends & Ten Cate, 1981).

Normally, the rate of demineralization/remineralization on the tooth surface are balanced due to the dynamic processes that are dependent on several factors, mainly on the presence of sugar which could be fermented by cariogenic microbes, host health factors and other associated environmental factors. Dental carries starts off with the mechanism of bacteria present on the tooth surface which metabolizes sugars to produce acid that causes calcium loss from the enamel layer and gradually demineralizes the hard tissues of the teeth (Gupta et al., 2020). Prolonged acid damage on teeth, resulted in erosion and carious lesions which are the two main consequences of unbalanced demineralization-remineralization processes (Abou Neel et al., 2016). The balance of remineralization/demineralization process is also affected by salivary flow and composition. In contrast, saliva acts as a replenishing source of minerals including calcium, phosphorus and fluoride ions which inhibits the demineralization of the enamel layer during periods of low pH and help to boost enamel remineralization when the pH returns to a neutral state.

Caries prevention at early stages from resulting in cavitated lesions requires meticulous and systematic methods for monitoring disease prior to the development of advanced lesions. Therefore, the prevention of dental caries is one of the greatest challenges in dentistry. There are vast strategies that may help to enhance oral health including improving oral hygiene practises, restricting sugar intake, and using new and effective toothpastes and toothbrushes (Bader et al., 2002). Nowadays, there has been the development of a number of innovative remineralization technologies for oral care application or dentifrices aiming at prevention of caries lesion at early stage. Due to the similar feature of biomimetic agents with natural tooth structure, great biocompatibility and its non- toxic chemical components, there is an increase of its usage in modern dentistry.

Variety of biomimetic agents have been commercialized for the treatment of early enamel carious lesion including fluoride, hydroxyapatite, and Casein Phosphopeptide–Amorphous

Calcium Phosphate (CPP-ACP) which are potentially curative regime for tooth demineralization. Fluorides are the gold standard and most prominent agent for dental caries prevention since its discovery. Fluoride compounds used in oral care are reported for its high potential in enhancing enamel remineralization process and to inhibit demineralization . Fluoride dentifrices have been extensively commercialized and found to be more efficacious for remineralization of root caries lesions (Philip, 2019). Previous study reported that toothpaste containing 1000 or 1100 ppm fluoride reduced the amount of decay in permanent teeth of children and adolescents compared with non-fluoride toothpaste (Walsh et al., 2019). However, there are raised concern of the use of high fluoride concentration in oral care products which may lead to the increases the risk of fluorosis in developing teeth (Grandjean & Landrigan, 2014). Despite fluoride-based dentifrices are effective in remineralizing enamel, they are incompetent to promote deposition of apatite nanoparticles in the enamel (Ruan & Moradian-Oldak, 2015).

Another emerging and promising biomimetic substance for oral care applications is calcium phosphate (CaP). CaPs are widely used in non-fluoride remineralizing system for their potential in preventing early caries lesions and its reparative properties towards minor enamel defects. There has been increased interest in developing bioactive agents based on CaP in oral care for enhancing enamel and dentin remineralization. Recently, vast majority of calcium phosphate remineralization systems were developed for oral care application including Casein Phosphopeptide-Amorphous Calcium Phosphate (CPP-ACP), Functionalized β-Tricalcium Phosphate (β-TCP), Calcium Sodium Phosphosilicate and Amorphous Calcium Phosphate (ACP). This bibliometric and scientometric analysis explores the interdisciplinary view of calcium phosphates-based for alternative oral care concepts in preventive dentistry. In this work, we have attempted to provide a global trend of publications and state of knowledge concerning the potential use of CaP in oral care application and preventive dentistry.

2. MATERIALS AND METHODS

The literatures were retrieved from the Scopus database for this bibliometric study. The chosen database covers a wide range of construction-related research. The retrieval of the publications was done on July 8, 2021. The existing literature related to calcium phosphate used in oral care research in this database was retrieved using the search parameters ((calcium AND phosphate) AND (dental AND caries) AND (remineralization)). The search period was set to include the last 10 years, from January 2011 to December 2021. The steps are shown in Figure 1.

The information for citation, bibliography, abstract, keywords, funding, and others were saved and exported in the CSV format. VOSviewer software was used to compute the scientometric analysis. This software is a tool that constructs and visualizes bibliometric networks. The bibliometric map represents the network system of each category. The software computes the data obtained on co-authorship, abstract, keywords, multiple occurrences of keywords in the titles and citations with similar references used in the literatures and generates the bibliometric maps. The keywords frequency while generating the bibliometric maps is set at desired and any irrelevant keywords are deleted.

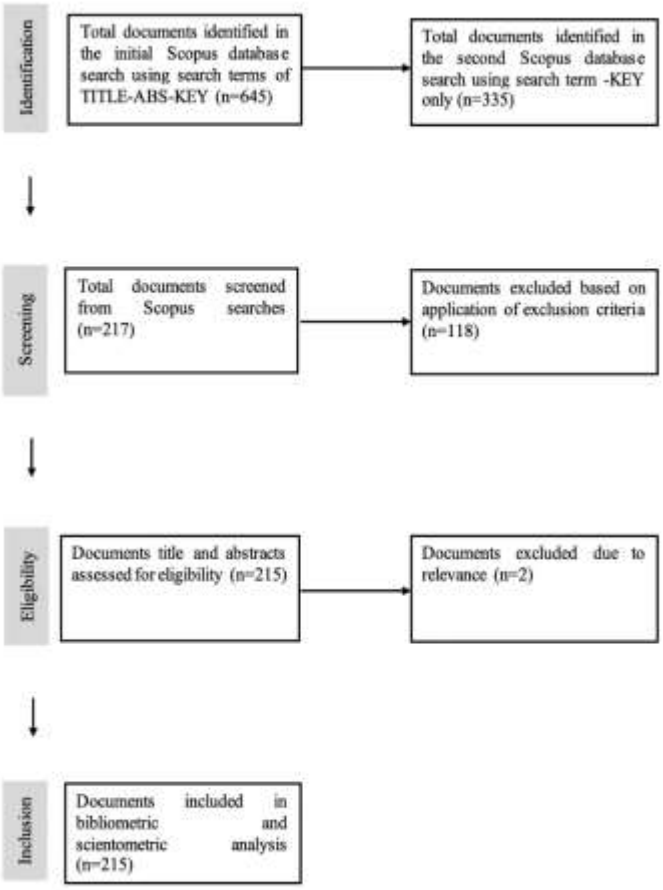

Figure 1. Steps in the bibliometric identification and screening of sources.

3. RESULTS AND DISCUSSION

3.1 Overal research trend by year of publication

To determine and visualize the current state of research on the application of calcium phosphate in oral care, publications regarding the topic including cumulative publications is plotted in a graph on a yearly basis (Figure 2). The number of publications could suggest the research patterns about calcium phosphate in oral care in the future. The research on the application of calcium phosphate in oral care was steady between 15 and 25 in 2011-2021 and the highest number of articles published in 2017. As a result, the cumulative

publication graph revealed a linear slope, indicating that academics worldwide did not pay much attention to this material's application in oral care.

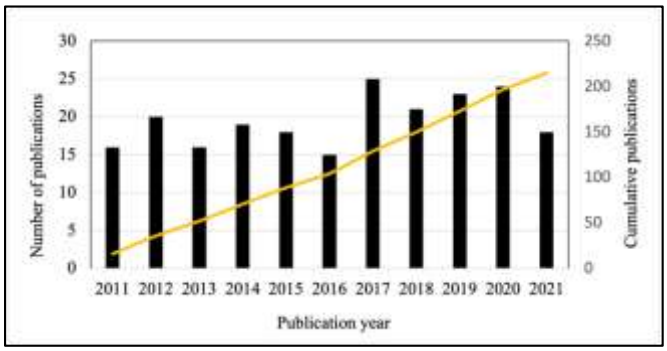

Figure 2. The number of publications and cumulative publications on a year-on-year basis

3.2 Country-wise distribution of publications

215 articles chosen in the analysis were published from 20 countries (Table 1). Highest number of publications can be observed coming from the United States (58 articles, 19.4% of the total documents), followed by China by 50 articles (16.7%) and India with 23 articles (7.7%). Both Australia and Brazil are in the 4th rank, with 20 articles published each (7.7%). Following that, two countries published articles in the range of 10 to 15 and 12 countries published articles in the range of three and nine. The overall number of publications is 268, which is more than the initial number 125 which shows that there is evidence on collaborative work in between the authors from different countries. Ten economically developed countries, shown by their position as a top 15 in terms of nominal GDP, have recognized the benefits of calcium phosphate in oral care. From the 58 number of publications produced, the United States had received the highest number of citations. Surprisingly, it shows that the United States was in second place (n=31) based on its average citation, followed by Italy, which had an average citation of 53 from three entire documents. Furthermore, China, United Kingdom, Thailand, and New Zealand are the countries with an average citation of 25 and higher. The links between countries collaborations on literature was also shown in Figure 3.

In order to measure the collaboration in between the countries, a point of measurement called Total Link Strength (TLS) analysis is employed. It is also shown in Figure 3 as the links between countries. The United States by far is the most collaborative country in research as showed by its TLS result of 254 (Table 1). Except for Indonesia and Singapore, the US had published documents in partnership with all of the countries listed. China obtained a TLS result of 247 which puts China in the second place. China's collaborative research was with the US, Japan, Saudi Arabia, Brazil, India, Thailand, New Zealand, Italy, the United Kingdom, and the Netherlands. According to the TLS score and the country cooperation network map, most countries have a strong research collaboration with the US and China.

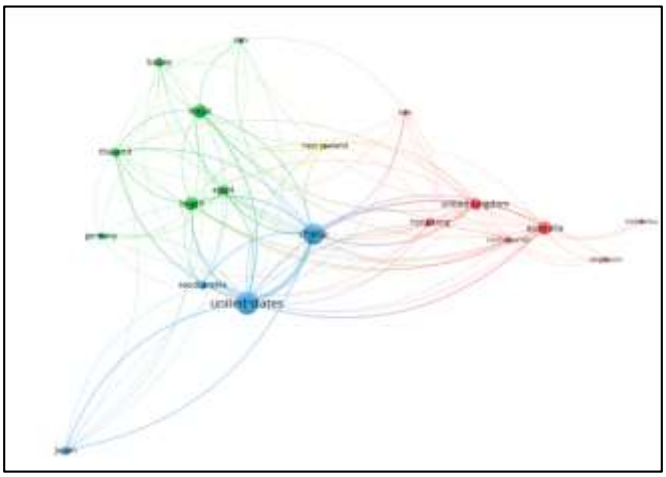

Figure 3. Country cooperation network on an application of calcium phosphate on dental caries research

3.3 Leading publishing organization analysis

Top organizations to have published more than three literatures are represented in Table 2. At least nine organizations had involved in publishing literatures throughout the year. The State Key Laboratory of Oral Diseases, National Clinical Research Centre for Oral Diseases, Sichuan University, Chengdu, from China had the highest number of articles published (n=13) which could bring its citations value to 574 and 50 average citations per article. After that, the Centre For Stem Cell Biology & Regenerative Medicine, School Of Medicine, University Of Maryland, Baltimore is in the second place with 11 articles published which resulted in a 207 citations value and an average of 73 citations per article. The Department Of Orthodontics, School Of Stomatology, Capital Medical University, Beijing had published eight articles with around 310 citations and 32 citations per articles published. Both Department Of Advanced Oral Sciences And Therapeutics, School of Dentistry, University Of Maryland, Baltimore and Marlene And Stewart Greenebaum Cancer Center, School Of Medicine, University Of Maryland, Baltimore shared the same number of articles (n=7) published. However, there are differences in the citations and average citations per articles value. Further, the Department Of Endodontics, Periodontics And Prosthodontics, School of Dentistry, University Of Maryland, Baltimore from the United States had published five articles. This resulted in a citation value of 143 and an average of 29 citations per articles. Lastly, three organizations with two from the United States (Department Of Mechanical Engineering, University Of Maryland, Baltimore, LRM Statistical Consulting, Hoboken, New Jersey) and one from China (VIP Integrated Department, Stomatological Hospital,

Table 1: Top countries that published more than three documents

#	Country	No. of article	Percentage (%)	No. of citations	Average citations per article	Nominal GDP Rank*	Total Link Strength
1	United states	58	19.40	1786	31	1	254
2	China	50	16.72	1364	27	2	247
3	India	23	7.69	381	17	6	81
4	Australia	20	6.69	243	12	12	62
5	Brazil	20	6.69	410	21	13	76
6	United Kingdom	14	4.68	420	30	5	58
7	Egypt	10	3.34	120	12	36	57
8	Turkey	10	3.34	107	11	20	16
9	Saudi Arabia	9	3.01	112	12	19	48
10	Japan	8	2.68	135	17	3	37
11	Thailand	8	2.68	198	25	25	57
12	Hong Kong	7	2.34	155	22	40	27
13	Germany	6	2.01	97	16	4	13
14	Netherlands	5	1.67	48	10	17	24
15	Iran	4	1.34	34	9	26	16
16	New Zealand	4	1.34	106	27	50	35
17	Canada	3	1.00	54	18	9	0
18	Indonesia	3	1.00	10	3	16	3
19	Italy	3	1.00	163	54	8	18
20	Singapore	3	1.00	9	3	39	7

* Nominal GDP Rank as per the International Monetary Fund (2019 estimates), World Economic Outlook Database, October 2019

Table 2: Top organizations that published more than three documents

#	Organization	Country	Articles	Citations	Average citations per article
1	Centre For Stem Cell Biology & Regenerative Medicine, School Of Medicine, University Of Maryland, Baltimore	United States	11	207	73
2	Department Of Advanced Oral Sciences And Therapeutics, School of Dentistry, University Of Maryland, Baltimore	United States	7	72	58
3	Department Of Endodontics, Periodontics And Prosthodontics, School of Dentistry, University Of Maryland, Baltimore	United States	5	143	39
4	Department Of Mechanical Engineering, University Of Maryland, Baltimore	United States	4	316	41
5	Marlene And Stewart Greenebaum Cancer Center, School Of Medicine, University Of Maryland, Baltimore	United States	7	296	53
6	State Key Laboratory of Oral Diseases, National Clinical Research Center for Oral Diseases, Sichuan University, Chengdu	China	13	574	50
7	Department Of Orthodontics, School Of Stomatology, Capital Medical University, Beijing	China	8	310	32
8	LRM Statistical Consulting, Hoboken, New Jersey	United States	4	198	1
9	VIP Integrated Department, Stomatological Hospital, Jilin University, Changchun	China	4	106	29

Jilin University, Changchun) shares the same number of articles published by four articles. However, the citation and average citations of the Department Of Mechanical Engineering, University Of Maryland, Baltimore had a superior value than the other two organizations. From the analysis, it can be concluded that the State Key Laboratory of Oral Diseases, National Clinical Research Center for Oral Diseases and Sichuan University are the pioneer organisations that are involved in the research of calcium phosphate in dentistry and orthodontics.

3.4 Publication map cluster

Clustering techniques plays a prominent role in identifying groups of related publications and citations. To summarize, 215 publications were found and 33 of them are most frequently cited publications which were used to generate the map for publication cluster. The map visualizes how the constantly cited publications group together. Figure 4 clearly illustrates the division of the cluster in that is represented in different colours for easy visualization. To indicate the specific research topic related to the clusters identified, the 19 clusters were examined manually. Quality of the published literatures is demonstrated by the links in between the citation which suggest that the quality of a paper is influenced by its citation metrics (Table 3).

A common indication of a good quality paper is by its high citation metric. It means numerous researchers around the world have been mentioning the literature and findings in their own research. In this review, 33 documents have been selected for further analysis based on their high citation value. The most-cited document was by Weir m.d. (2012) which reported the significant level of remineralization of enamel of spray-dried amorphous calcium phosphate formulation compared to the traditional control which releases fluoride by four-fold. Second paper with the most citation is a review paper that discussed the future prospects of dental caries management strategies that utilizes functional nanoparticles which possesses antimicrobial and regenerative properties (Melo, 2013). Finally, the third most mentioned document was on the promising value of nano-HA in repairing the tooth based on its enhancement effect to the regeneration pathways of minerals (particle and ion-mediated) (Huang, 2011). Among the top three cited literatures discussed, the literatures with the most number of citations (four times) was produced by Weir m.d and Li. Both J. Weir m.d and Li. J had been cited by Liu Y, Huang S, Li J, Poggio, Robertson. It is noticeable in Figure 4 that there was one prominent and highly interrelated cluster of Weir and Li J groups. In general, it can be suggested that this cluster had represented the most significant literatures that had the most impact on calcium phosphate-based dentifrices research.

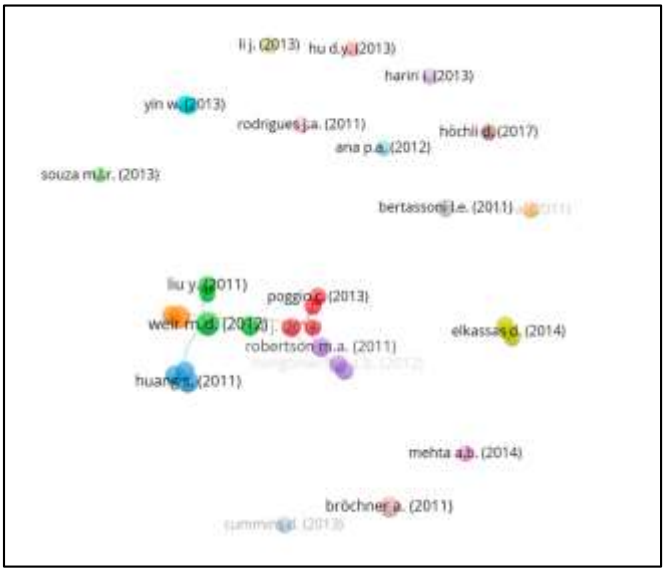

Figure 4. Documents and citations relationship of the publications that have been cited for at least forty times.

3.5 Distribution and co-citation relationship

The relationships between journals preferred by the authors in publishing their work is illustrated in Figure 5. The citations are important for these journals as it resembles their quality. It can be concluded that most of the authors prefers to publish their work on calcium phosphate in the Journal of Dentistry. Currently, 25 articles have been published by the journal. These articles have been cited significantly for 760 times. Second place was taken by Caries Research where 12 articles was published by the journal and with 431 citations. Journal titled Dental Materials was in the third place with ten articles publishes and 372 citations. It can be observed that these three top journals have the highest value for Total Link Strength (TLS) compared to the others. This suggest that these journals are commonly cited by authors who published their article in other journals. This can be visualized and confirmed in the source and citation relationship map generated. For the highest number of average citations, the American Journal of Orthodontics and Dentofacial Orthopaedics, Dental Materials and Caries Research were in the top three respectively. It is safe to say that the research work published in these journals are very impactful towards this area of research. This is due to the fact that these journals have a high quartile ranking. According to the Scimago database by Scopus, all the journals are in the Q1 ranking. Further, both Dental Materials (IF: 5.304) and Caries Research (IF: 4.056) are also listed as Q1 ranking in the Journal Citation Reports by Clarivate.

Table 3: Top documents that have been cited for at least forty times

#	Article	Citations	Links	Reference
1	Weir m.d. (2012)	145	4	(Weir et al., 2012)
2	Melo m.a.s. (2013)	134	2	(Melo et al., 2013)
3	Huang s. (2011)	117	1	(Huang et al., 2011)
4	Bröchner a. (2011)	94	0	(Bröchner et al., 2011)
5	Cheng l. (2015)	89	3	(Cheng et al., 2015)
6	Robertson m.a. (2011)	82	3	(Robertson et al., 2011)
7	Cheng l. (2017)	76	1	(Cheng et al., 2017)
8	Zhang l. (2016)	76	2	(Zhang et al., 2016)
9	Liu y. (2011)	75	1	(Liu et al., 2011)
10	Nongonierma a.b. (2012)	74	2	(Nongonierma & FitzGerald, 2012)
11	Li j. (2014)	73	4	(Li et al., 2014)
12	Bertassoni l.e. (2011)	73	0	(Bertassoni et al., 2011)
13	Besinis a. (2012)	72	1	(Besinis et al., 2012)
14	Jayarajan j. (2011)	72	1	(Jayarajan et al., 2011)
15	Poggio c. (2013)	62	1	(Poggio et al., 2013)
16	Yin w. (2013)	59	1	(Yin et al., 2013)
17	Elkassas d. (2014)	58	2	(Elkassas & Arafa, 2014)
18	Zhou c. (2014)	58	3	(Zhou et al., 2014)
19	Srisilapanan p. (2013)	56	1	(Srisilapanan et al., 2013)
20	Karlinsey r.l. (2012)	56	1	(Karlinsey & Pfarrer, 2012)
21	Zhang q. (2011)	56	1	(Zhang et al., 2011)
22	Weir m.d. (2017)	50	2	(31)
23	Mehta a.b. (2014)	50	0	(Mehta et al., 2014)
24	Sitthisettapong t. (2012)	50	3	(Sitthisettapong et al., 2012)
25	Ana p.a. (2012)	50	0	(Ana et al., 2012)
26	Rodrigues j.a. (2011)	50	0	(Rodrigues et al., 2011)
27	Rao a. (2011)	48	0	(Rao & Malhotra, 2011)
28	Cummins d. (2013)	47	0	(Cummins, 2013)
29	Hariri i. (2013)	46	0	(Hariri et al., 2013)
30	Li j. (2013)	45	0	(Chen et al., 2013)
31	Höchli d. (2017)	44	0	(Höchli et al., 2017)
32	Souza m.l.r. (2013)	42	0	(Souza et al., 2013)
33	Hu d.y. (2013)	41	0	(Hu et al., 2013)

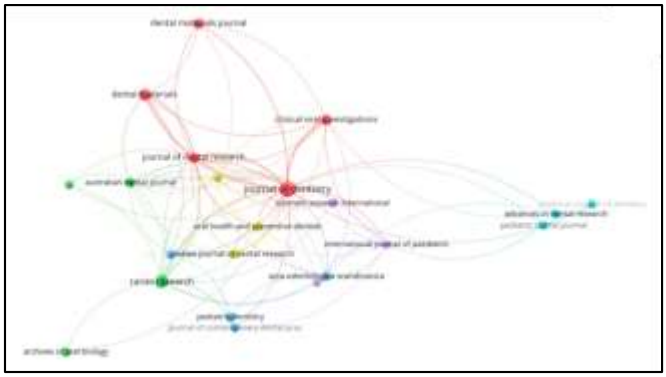

Figure 5. Source and citations relationship of the sources that published documents on an application of calcium phosphate on dental caries research.

3.6 Cluster density: application of calcium phosphate in oral care

A density map is generated by analyzing the co-occurrence of all keywords on calcium phosphate in oral care (Figure 6). To specifically visualize the use of calcium phosphate in dentifrice, the keywords were selected manually. The density visualization map is interpreted as such: the denser the keywords used are, the darker the yellow color and the larger the circle's size, indicates that there are more people conducting research on that specific topic. Final analysis of the density map suggests that terms such fluoride, casein and calcium phosphate are connected strongly with a variety of dentifrices used in oral application.

Dental caries is among the main issues highlighted and which draw the attention of researchers at present. A consistently increasing trend for publications over the past ten years reflects the expansion of world - wide interest in caries research. The driving factors that stimulate the growing demand in caries research are the challenges of finding appropriate treatment and prevention for dental caries. Biomimetic properties are the most popular topic discussed regarding the oral care application. According to the Scopus database, the number of publications that relate to "calcium phosphate" and "enamel remineralization" increased rapidly between 2011 (n=16) and 2021 (n=215). The trend and distribution pattern from Figure 2 indicates that research of calcium phosphate, especially studies related to teeth remineralization, is attracting increased attention from scientists and the academic community. Currently, dental substances such as fluoride, CPP and calcium phosphate are among the most common materials discussed for dentifrice formulation, due to their abundant nature, low- cost, non-toxicity, and compatibility with the applications. Previously, fluoride-based agents enhanced remineralization in the presence of critical pH, inhibit plaque glycolysis, and promote the formation of high-quality fluorapatite. Fluoride has bactericide and bacteriostatic properties that act on microorganisms in the oral cavity, such as *Streptococcus mutans*.

In modern oral care strategies, calcium phosphates have been identified as promising biomimetic alternatives due to their similarity to natural enamel. Calcium phosphate materials are widely used as an alternative and non-fluoride agent that improve remineralization without having any possible side effects on the human body. The clinical use of calcium phosphate in caries protection shows an equal or superior efficacy in remineralization compared to fluorides and provide an efficient caries protection in vivo. It is assumed that calcium phosphate functions by infiltrating the micropores in early caries lesions, where it acts as crystal nuclei in the remineralization process by continuously attracting large amounts of calcium and phosphate ions from the oral fluids into the lesion, thus promoting natural remineralization processes. Besides remineralizing properties, in situ studies with hydroxyapatite have shown anti-adhesive properties that have the potential to be employed for a biomimetic biofilm control (Meyer et al., 2018). Microorganisms tend to attach to free hydroxyapatite particles originating from toothpaste or mouth rinse and are thus cleared from the oral cavity, since they are deprived from colonizing the enamel (Kensche et al., 2017). It is also reported that hydroxyapatite forms a protective layer on the enamel surface (Lacruz et al., 2017). Both remineralization concepts, i.e., calcium phosphates alone or in combination with fluorides have been realized in modern oral care products. However, it is important to know that combining calcium phosphates with fluorides within a toothpaste formulation may reduce the bioavailability of (ionic) fluoride in the oral cavity. This is due to the reaction of fluoride with calcium forming insoluble compounds such as Calcium Fluoride, CaF_2, or Fluorapatite $Ca_5(PO_4)_3F$ (Epple et al., 2022).

Currently, studies on the analysis and quantification of enamel remineralization *in vivo* are still a challenge in oral care research. In general, Scanning Electron Microscopy (SEM) is ideally used to visualize morphological changes in tooth erosion whereby micro-radiography is used for advanced cases (Schlueter et al., 2011). Moving further with time, the study of biomimetics such as calcium phosphate would greatly be improved by the development of advanced methods (Pandya & Diekwisch, 2019). The most feasible part of calcium phosphate is the fact that it is abundant in wastes. For instance, remains of marine life such as clam shells, oyster, razor, sea snail shells are one of the inexpensive alternatives of hydroxyapatite and tricalcium phosphate (Terzioğlu et al., 2018). Studies on using these sources of calcium phosphate and applying it in dental care seems a promising approach in re-utilizing wastes back into the human consumption.

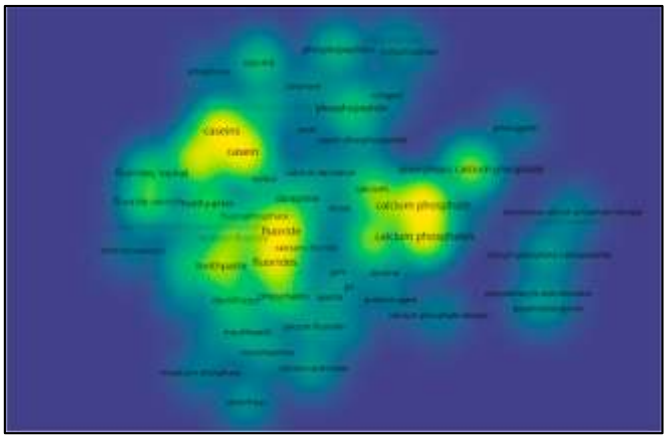

Figure 6. Density visualization map of the different elements used in dentifrice formulations.

4. CONCLUSION

The current scientometrics analysis makes several important contributions to dentifrice material using calcium phosphate subject, based on a bibliometric study. In gist, the information on 215 articles related to the research area mentioned above was extracted from the Scopus database. The scientometric analysis was performed on the extracted information of the calcium phosphate materials which are currently used in dentistry and other calcium phosphate materials which have potential for dental applications. Global trends and recent publications of calcium phosphate materials in oral care application are discussed. Further, this paper had highlighted major authors and researchers who greatly contributed into the research of calcium phosphate in oral applications. Although there was major improvement and profound interest of calcium phosphate materials for dental caries research, further studies are needed to confirm their properties.

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REVIEW ARTICLE

Analyses of phytochemical constituents in *Justicia gendarussa* extract: A mini review

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Abstract:

Justicia gendarussa is a plant from the Acanthaceae family with numerous medicinal benefits. Several studies have reported the phytochemical compounds of *J. gendarussa* extract however, the method used for detection of the chemical constituents have not been reviewed. Hence, the purpose of this review is to look at various methods used in the detection of chemical constituents of the *J. gendarussa* extract. Previous research were collected from Google Scholar which resulted in thirty-seven articles related to *J. gendarussa* and detection of its phytochemical constituents. From the review, detection methods involved were qualitative screening, thin layer chromatography, liquid chromatography, and gas chromatography. While phytochemical compounds detected were alkaloid, anthraquinons, betacyanin, linoleic acid, oleic acid, apigenin, kaempferol, naringenin, vitexin, Gendarusin A, glycosides, anthocyanin, tannins, carotenoids, saponins, steroids and carbohydrates. Results of analysis demonstrated that every method has its advantages and disadvantages. Therefore, this review will help researchers in choosing the best and most suitable method for phytochemical analysis depending on their need and interest.

Keywords: detection, *Justicia gendarussa*, phytochemicals

1. INTRODUCTION

Justicia gendarussa is a medicinal plant from the Acanthaceae family. It is a moist, fast growing, and evergreen plant found mainly in humid areas (Nirmalraj & Perinbam, 2015). Hence it is mostly found in Indonesia, Africa, Brazil, and Central America (Ramees et al., 2019). However, it also found in India, China, Malaysia, Sri Lanka, the Philippines, and Bangladesh (Ningsih et al., 2015). Since it can be found in many places, this plant is called by many different names according to different regions such as in Malay it is called 'Daun Rusa' (Khare, 2007), 'Black adusa' in English (Saha et al., 2012) and in Myanmar it is commonly known as pha-wa-net (Aye et al., 2019). In Tamil it is called as 'Karunocchi', 'Kala bashimb' in Hindi, and 'Bhutakeshi' in Sanskrit (Pal & Rahaman, 2015).

This plant is a branched undershrub and 0.8 to 1.5 m high with long leaves. The leaves are flat, lanceolate or linear lanceolate, light green underneath and dark green on top. The roots and the stems are dark violet. Flowers from the uppermost axils of the leaf are 5-12,5 cm long; white colored with purple spots and clustered in interrupted spikes (Vijayakumar et al., 2019; Raghu & Agrawal, 2016).

According to the World Health Organization (WHO), nearly 80% of the world's population utilize plant extracts and its constituent as medication in traditional therapies (Neena et al., 2019). Similarly, *J. gendarussa* have been traditionally used as remedies for various diseases. In traditional Indian and Chinese medicine, the plant's leaf is prescribed for the treatment of diseases such as fever, hemiplegia, rheumatism, arthritis, headache, earache, muscle pain, respiratory disorders and digestive disorders (Nirmalraj & Perinbam, 2015). In the Papuan tribe in Indonesia, *J. gendarussa* is used traditionally for male contraception by decreasing the concentration of testosterone and the dispersibility of cumulus oophorus *in vitro* (Mnatsakanyan et al., 2018). Therefore, it could reduce spermatozoa hyaluronidase (Matsunami, 2018). In addition, it has also been used in the treatment of bronchitis, eye infections, vaginal discharges, dysentery, eczema and jaundice (Venkatachalam et al., 2019). As for scientific studies, various parts of the plant have been explored such as their leaves and roots for their various phytochemical, antibacterial and antioxidant properties (Kumar et al., 2017).

Phytochemical analyses are very useful in determining the chemical components of medicinal plants which will give insights on their potential health benefits. The phytochemical screening carried out on *J. gendarussa* leaves extract indicated the existence of several active compounds that play vital roles in fighting diseases. Some of the compounds reported by previous studies were carbohydrates, glycosides, alkaloids, flavonoids, tannins, saponins, phenolic

compounds, steroids and triterpenoids (Prasad et al., 2017; Vijayakumar et al., 2019). To detect the phytochemicals present in the extract there are various methods of detection which can be used including the qualitative and quantitative analysis. Qualitative analysis is used to determine the presence of compounds such as alkaloids, tannins, amino acids, flavonoids, phenols, carbohydrates, proteins, saponins and glycosides via visible chemical reactions. There are also other methods that can be used to analyse them both qualitatively and quantitatively at once. Examples are thin layer chromatography, gas chromatography and liquid chromatography methods. However, until today, no review on the methods used to determine the *J. gendarussa* constituents has been published. Thus, this study aims to review the various methods used in detection of chemical constituents of *J. gendarussa*. Based on previous research, methods used in the detection of chemical constituents as well as the various phytochemical constituents found in *J. gendarussa* were summarized.

2. RESULTS AND DISCUSSION

2.1 Analyses of *J. gendarussa* extract

2.1.1 Qualitative Screening

Qualitative phytochemical screening is the first step to determine the existence of chemical compounds in the *J. gendarussa* extract. Most researchers began their study by conducting the preliminary phytochemical analysis which qualitatively examine the plant extract before proceeding to quantitative analysis. This method allows researcher to detect the presence or absence of various types of phytochemical constituents. In general, qualitative analysis involves chemical tests using reagents against the *J. gendarussa* extract. Resulting chemical reaction will indicate the existence of the compound of interest. Results of the tests will be reported as presence or absence of the chemical compound in the plant extract. Table 1 demonstrates a few examples of the tests.

Based on the qualitative screening analysis done by previous researchers, several chemical constituents were evidently found in the *J. gendarussa* extract. The chemical constituents that have been found through this method were carbohydrates (Ramees et al., 2019; Vijayakumar et al., 2019; Kumar et al., 2017), glycosides (Nirmalraj & Perinbam, 2015; Kumar et al., 2017; Vijayakumar et al., 2019), alkaloids (Nirmalraj & Perinbam, 2015; Kumar et al., 2017; Ramees et al., 2019; Vijayakumar et al., 2019), flavonoids (Nirmalraj & Perinbam, 2015; Kumar et al., 2017; Ramees et al., 2019; Nongmaithem, 2019; Vijayakumar et al., 2019), tannins (Nirmalraj & Perinbam, 2015; Kumar et al., 2017; Ramees et al., 2019; Vijayakumar et al., 2019) and saponins (Nirmalraj & Perinbam, 2015; Kumar et al., 2017; Ramees et al., 2019; Vijayakumar et al., 2019). Furthermore, phenols (Nirmalraj & Perinbam, 2015; Ramees et al., 2019), steroids (Vijayakumar et al., 2019), anthraquinons (Nirmalraj & Perinbam, 2015), terpenoids (Nirmalraj & Perinbam, 2015), protein (Kumar et al., 2017), betacyanin (Kumar et al., 2017) and anthrocyanin (Kumar et al., 2017) have also been found in the plant extract.

Table 1. Procedures for phytochemical screening and indications for presence of compound.

Test	Procedure	Indication for positive result
Alkaloids (Mayer's test)	2mL of 2N hydrochloric acid (HCl) and Mayer's reagent (Potassium mercuric iodide solution) are mixed together with 1 mL of crude extracts.	Formation of a turbid white creamy precipitate.
Flavonoids	In 1mL of crude extracts, a few drops of 1% Ammonia (NH_3) are added.	An intense yellow colour.
Glycosides	1mL of crude extract and 1mL of concentrated sulphuric acid are mixed together. Fehling's solution is added to the solution.	A black-red precipitate
Tannins	1mL of crude extract is pipetted with 2mL of % $FeCl_3$.	A blue-black precipitate.
Terpenoids	In 0.5mL of acetic anhydride, 1mL of crude extract is dissolved. The mixture is added with few drops of concentrated sulphuric acid.	A bluish green precipitate.
Saponins	5ml of crude extract is mixed together with 5ml of deionized distilled water in a falcon tube. Then, the mixture is shaken vigorously.	Presence of foam that last for 15 minutes.

2.1.2 Thin Layer Chromatography

Thin layer chromatography is one of the separation methods used in the detection of chemical constituents of *J. gendarussa* extract. In this method, a piece of glass, metal or rigid plastic is used and coated with a thin layer of silica gel as the stationary phase (Altemimi et al., 2017). Silica gel was covered all over the surface of the plate. The effectiveness along with the nature of separation of the plate can be increased by lowering the thickness of the silica layer (Banu & Cathrine, 2015). In terms of *J. gendarussa*, the thickness

of the thin layer of silica gel that have been applied by previous researchers were 0.25 mm (Patel & Zaveri, 2014; Widodo et al., 2018; Neena et al., 2019).

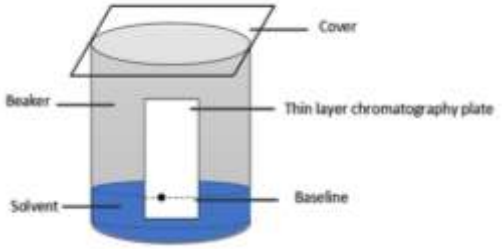

Figure 1. Simple schematic diagram of Thin Layer Chromatography

In this method, solvent is used as the mobile phase and is put together into the glass chamber as demonstrated in Figure 1. Using different ratio of solvents will elute the sample easier and give a better separation in the mobile phase. In the preparation of *J. gendarussa* extract, researchers used different kinds of solvents at various ratios. For example, the study by Neena et al. (2019) used petroleum ether and acetone in a ratio of 1:1. On the other hand, Widiyanti et al., (2018) used chloroform and methanol in a 9:1 ratio while Patel and Zaveri (2014) prepared alcoholic concentrate of leaf using n-butanol: formic corrosive (4.5:0.5). Some studies even used more than two types of solvents such as the usage of butanol: glacial acetic acid: water (4:1:5) by Widiyanti et al. (2018) to determine the alkaloid and flavonoid compounds of *J. gendarussa* leaves. In 2014, Patel and Zaveri used n-butanol: methanol: water: formic corrosive in a 2.5:1:1:0.5 ratio as the mobile phase in their study.

Solvent and the silica coated plate will then be put in a chamber as the elution process needs to be done in a closed system such as in a beaker or a glass chamber. The most desirable saturation condition is at relative dampness of 60% ±5 for 30 minutes at room temperature (Patel & Zaveri, 2014). In the chamber, the solvent will tend to move upwards towards the end of the plate by capillary action (Kumar et al., 2013). Different chemical constituents of the plant extract will stop at different locations based on the polarity of the components in the extract. Observation of the separated chemical constituents can be done using ultraviolet (UV) lamp or chemical stains for the non-active UV compounds. To aid the observation process of the chemical component present in the *J. gendarussa* extract, Widodo et al. (2018) have used Dragendorf reagent for alkaloid detection and borate citric for flavonoid detection. As for Patel and Zaveri (2014), separated chemical constituents of *J. gendarussa* extract were seen under UV light at 254 nanometer (nm) and 366 nm. Once detected, the spots can be used in the determination of the polarity and qualitative description of the molecules by calculating the ratio distance travelled by the compound and the solvent known as retention factor (Rf value) (Patel & Zaveri, 2014).

Some of the advantages from using this method are it is a simple procedure to set up and the cost involved is not expensive. Hence it is suitable for studies with low budget (Altemimi et al., 2017). This method also only takes about 30-60 minutes to run for qualitative analysis of any compounds (Kumar et al., 2013). However, the thin layer chromatography method is only applicable to non-volatile compound and it is not a fully automated procedure hence it might lead to misinterpretation of the results.

Various research has been carried out using thin layer chromatography method in detection of phytochemical constituents of *J. gendarussa* extract. Study by Patel and Zaveri (2014) has found several compounds such as phenolic, carbohydrate, flavonoid, steroid, carotenoid, alkaloid, and triterpenoid from the extract. Another study by Widodo et al., (2019) had detected compounds such as alkaloid, flavonoid, phenolic, saponin and steroid. However, some studies only used this method to specifically detect alkaloid and flavonoid in the *J. gendarussa* extract (Widiyanti et al., 2018; Widodo et al., 2018 Neena et al., 2019).

2.1.3 Liquid Chromatography

Liquid chromatography is another method usually used in the separation of phytochemical constituents of plant extract. This method still adheres to the same principle as other chromatography method which is the involvement of stationary and mobile phases. However, in this method, sample is injected into the mobile phase and then passes through the column as illustrated in Figure 2. Example of column used is column made of silica (2.2 µm, 120 Å, 2.1 x 100 mm) which was used in the study conducted by Ningsih et al., (2015) and Ratih et al., (2019) to identify the *J. gendarussa* chemical compounds.

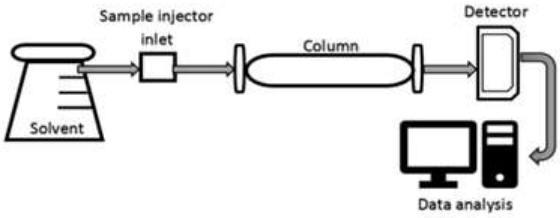

Figure 2. Simple schematic diagram of Liquid chromatography system

In the liquid mobile phase, sample will flow through the column by gravitational force and become separated. Non-polar or less polar solvent is preferable when choosing the solvent to aid the separation process. Non-polar compound will flow down the column faster than polar compound because polar compounds have the tendency to become attached to the column surface longer. In 2019, study by

Ratih et al. has used a mixture of ammonium acetate and methanol as their mobile phase to identify phytochemical constituents of *J. gendarussa* extract. Mobile phase used by Ningsih et al., (2015) also consisted of ammonium acetate and methanol. Results of the separation process will be interpreted by a detector connected at the exit of the column. One of the detectors which is commonly used is mass spectrometer. It can be used to identify and quantify the compounds based on their molecular weight (Ningsih et al., 2015; Ratih et al., 2019).

On the other hand, high performance liquid chromatography (HPLC) is an upgraded version of the liquid chromatography method (Pang et al., 2016). The HPLC method still maintains the stationary phase and mobile phase such as that of the liquid chromatography technique. However, the procedures involved in inserting sample and solvent into the column is slightly different than that of liquid chromatography method. To introduce solvent-sample mixture into the column, it uses a high-pressure pump with a constant flow rate as shown in Figure 3 (Feng et al., 2019). The usual optimal constant rate used by previous researchers was 1mL/min (Raghu & Agrawal, 2016; Mnatsakanyan et al., 2018). This is to aid the process of separation of compounds before they flow out of the column. To reach the detector, the speed of every compound depends on the it's nature and the mobile phase used. Once the separation process ends, the compounds will come out of the column and flow to the connected detector. Previous study by Mnatsakanyan et al., (2018) utilized a column with 250 mm of length, 4.6 mm of internal diameter and a solvent system which consisted of methanol and water in their research on quantitative evaluation of male contraceptive property of *J. gendarussa* extract and identification of a new amino benzyl derivative. However, Raghu and Agrawal, (2016) used a column with the exact same size but used a mixture of acetonitrile and 0.1% orthophosphoric acid instead for the mobile phase.

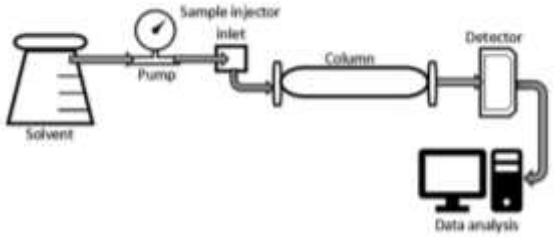

Figure 3. Simple schematic diagram of High-performance liquid chromatography system

To detect the resulting compound, Raghu and Agrawal (2016) used the UV detector for the detection of vitexin in the *J. gendarussa* extract. Detection was conducted using the intensity of the UV light at wavelength 335 nm. Another type of detector which had been used to determine the phytochemical constituents in the plant extract especially for non-volatile compounds, is evaporative light scattering detector (ELSD). ELSD was used under the parameters of 45°C temperature and pressure of 3.5 bar for the profiling and quantification of the compounds found in *J. gendarussa* extract (Mnatsakanyan et al., 2018).

Each method has its own benefits and limitations. Liquid chromatography method, prior to being upgraded into HPLC method, was an efficient method to separate compounds at low temperature. However, its' disadvantage was it is time consuming. This is because in liquid chromatography method, the flow rate of solvent fully depends on the gravity during the elution process (Thammana, 2016). In the following years, HPLC was introduced and has become the choice of many researchers due to its privileges. For instance, the amount of sample and solvent required in the procedure were reduced and it produced results with high sensitivity (Zhu & Chen, 2017). HPLC was also less time consuming with high rate of sensitivity (Vare et al., 2019). This method is also suitable for analysis of compounds that are either insoluble or poorly soluble in water (Juszczak et al., 2019). Nonetheless, HPLC method is a quite complicated procedure and requires a skilled and knowledgeable person to operate the system (Zhu & Chen, 2017) and at the same time it is costly (Vare et al., 2019).

Liquid chromatography mass spectrometer analyses by Ratih et al., (2019) have revealed the presence of thirty-five metabolites in the *J. gendarussa* extract. They found that the major constituents were alkaloids, fatty acids and apigenin glycosides. Their findings were more extensive compared to that of Ningsih et al., (2015) in which only six compounds were proposed from their study. There were justidrusamide A or justidrusamide B, 6-desmethylprazosin or 7-desmethylprazosin, 1,5-dideoxy-3-C-[({5-hydroxy-2-[(5-oxooxolane-2-carbonyl)-amino]phenyl}methoxy)carbonyl] pentitol,6,8-di-C-α-L-arabinosyl-apigenin,4-[(morpholin-4yl)(oxo)acetyl]phenyl hexopyranoside, and justidrusamide C or justidrusamide D. In 2016, Raghu and Agrawal had reported, in accordance with their main objective which was to identify vitexin in the leaves extracts of *J. gendarussa*, the identification of vitexin by using the HPLC method. By using ELSD, Mnatsakanyan et al., (2018) found three main constituent peaks in the methanol extract. The three main peaks were gendarusin A, justidrusamide A, and justidrusamide B. Other minor constituents were justidrusamide C, justidrusamide D, and justidrusamide E.

2.1.4 Gas Chromatography

Another method which has been used to separate different types of compounds in *J. gendarussa* extract is gas chromatography. Gas chromatography is a separation technique using a column as the stationary phase. The column also functions as the holder for the sample. The main difference between liquid chromatography and gas chromatography is the mobile phase used. In the liquid chromatography method, a solvent is used as its mobile

phase, while inert gas is used in the gas chromatography method (Hadi & Hameed, 2017). The most common carrier gases used by researchers was helium or nitrogen (Coskun, 2016). There have been a few studies which utilized helium as their mobile phase with the flow rate between 1.0 ml/min to 1.3 ml/min (Ayob et al., 2017; Wahyuni et al., 2017; Yadav et al., 2017). In addition, the inner wall of the capillary column is coated with liquid stationary phase to increase the sensitivity of the separation process (Rahman et al., 2015). Figure 4 demonstrates the schematic diagram of a gas chromatography apparatus.

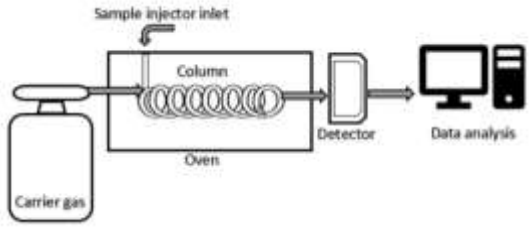

Figure 4. Simple schematic diagram of Gas chromatography system

In previous studies involving the use of gas chromatography for the detection of phytochemicals within the *J. gendarussa*, several types of columns have been used. Yadav et al., (2017) had utilized a column with 30.0 m length, 0.25 mm width and film thickness of 0.25 µm. However, a fused silica capillary column (30.0 m × 0.32 mm, film thickness 0.25 µm) was used by Ayob et al., (2017) in their studies. Besides that, study by Wahyuni et al., (2017) used a capillary column coated with 5% phenylmethyl siloxane, 30.0 m length, 0.32 mm width and 0.2 um of film thickness to examine the phytocomponents of methanolic extracts of the *J. gendarussa*.

Similar to liquid chromatography, sample loaded into the column is in the liquid state. Study done by Murugesan (2017) had used three types of solvents including methanol, chloroform, and oil ether while a study by Ayob et al., (2017) used crude extract of *J. gendarussa* leaves. When the column is heated, the sample is instantly vaporised and become mixed with the carrier gas. The column's temperature will then be gradually increased and then maintained at a temperature that has been set throughout the process. This is to allow the elution process of low boiling and less volatile compounds at low temperature, while high boiling compounds at higher temperature. Study by Yadav et al., (2017) had used a temperature range of 60°C to 300°C with a rate of 10°C/min. In comparison, Wahyuni et al., (2017) used a slightly lower temperature which was 50°C-280°C with a rate of 100°C/min and Ayob et al., (2017) used 100°C-275°C with the rate of 10°C/min. Heating the column will allow the sample to become vaporized then be carried by the mobile phase. The rate of migration relies upon the number of chemical compounds scattered in liquid phase. The higher the level of compound in the gaseous form, the faster the migration process to the exit of the column (Banu & Cathrine, 2015). As shown in Figure 4, a detector is attached at the end of the column to record the time when the compounds reached the detector. The type of detector normally used by researchers in their study on *J. gendarussa* were mass spectrometer (Murugesan, 2017; Wahyuni et al., 2017; Yadav et al., 2017) and flame ionization detectors (Ayob et al., 2017).

Benefits of using gas chromatography for phytochemical analysis are its simplicity, sensitivity, and effectiveness (Hadi & Hameed, 2017). Aside from these advantages, it is useful for detection of volatile compounds. However, the drawback is that the gas chromatography method is ineffective for non-volatile compounds (Xu et al., 2017). Furthermore, the use of inert gases such as helium as the mobile phases in this method is hazardous and costly (Juszczak et al., 2019).

The use of gas chromatography method in the detection of chemical compounds in the *J. gendarussa* extract resulted in discovery of various compounds which have also been reported by previous studies. GC-FID (gas chromatography-flame ionization detector) was used to detect and quantify naringenin and kaempferol compounds contained in young and mature leaves in *J. gendarussa* (Ayob et al., 2017). The study by Yadav et al., (2017) has shown the presence of oleic acid, 9,12-octadecadienoic acid, 6,9,12-octadecatrienoic acid and estra-1, 3,5 (10)-trein-17-β-ol in the *J. gendarussa* extract. In addition, studies conducted by Murugesan (2017) and Wahyuni et al., (2017) have successfully detected 23 and 26 compounds, respectively.

2.2 Phytochemical constituents of *J. gendarussa* extract

Based on the studies reviewed, there were many chemical constituents found in *J. gendarussa* extracts by using various methods of detection. Each chemical constituent has their own benefit and medicinal usage. The important chemical constituents detected in the *J. gendarussa* extracts and their medicinal usage for human are as listed in Table 2.

Table 2. Important chemical constituents detected in *Justicia gendarussa* extracts and their medicinal usage for human.

Chemical constituents	Medicinal usage	References
Alkaloid	Anti-inflammatory, Anticancer, Antimicrobial, Antifungal, Analgesic, Anesthetic, Neuropharmacologic, Pain reliever.	(Patel & Zaveri, 2014; Nirmalraj & Perinbam, 2015; Kumar et al., 2017; Widiyanti et al., 2018; Ramees et al., 2019; Neena et al., 2019; Ratih et al., 2019; Vijayakumar et al., 2019; Widodo et al., 2019)

Anthraquinons	Antibacterial, Anti-fungal, Antiviral, Antioxidant, Constipation reliever.	(Nirmalraj & Perinbam, 2015)
Betacyanin	Antioxidant, Anticancer.	(Kumar et al., 2017)
Fatty acid (Linoleic acid)	Anti-inflammation, Anticarcinogenic, Anti-arthritic, Antieczemic, Antiacne, Nematicide, Insectifuge.	(Yadav et al., 2017)
Fatty acid (Oleic acid)	Induce apoptosis in carcinoma cells.	(Yadav et al., 2017)
Flavonoid (Apigenin)	Antidepressant, Antitumor, Anti-inflammatory, Antioxidant.	(Ratih et al., 2019)
Flavonoid (Kaempferol)	Inhibit cell proliferation, antioxidant, Prevent arteriosclerosis	(Ayob et al., 2017)
Flavonoid (Naringenin)	Antiproliferative, Antibacterial, Anticarcinogenic, Cholesterol lowering agent, Help fight retinal disease linked to diabetes.	(Ayob et al., 2017)
Flavonoid (Vitexin)	Prevent heart disease	(Raghu & Agrawal, 2016)
Flavonoid (Gendarusin A)	Male contraceptive properties, anti-HIV.	(Mnatsakanyan et al., 2018)
Glycosides	Antioxidant, Antitumor, Anticancer, Anti-diabetes, Hepaprotective.	(Nirmalraj & Perinbam, 2015; Kumar et al., 2017; Ramees et al., 2019; Ratih et al., 2019; Vijayakumar et al., 2019)
Phenols (Anthocyanin)	Anti-allergic, Anti-inflammation, lowering blood pressure and reduce tumor growth.	(Kumar et al., 2017)

3. CONCLUSION

The existence of chemical constituents of the plant can be determined by carrying out analyses using standard procedures. As for the detection and quantification of phytochemical compounds in the *J. gendarussa* extract, previous researchers have used various types of methods. Qualitative screening is the preliminary screening step in the detection of chemical compounds in the *J. gendarussa* extract. As for the detection and quantification of phytochemical compounds in the extract, previous researchers have used various types of chromatography methods.

Chromatography is a method used to separate compounds in a mixture that involves a mobile phase and a stationary phase. The chromatographic techniques which have been used by several groups working on *J. gendarussa* extracts were thin layer chromatography, liquid chromatography, and gas chromatography. Thin layer chromatography is the simplest procedure, but it is not fully automated. HPLC is less time consuming compared to liquid chromatography but in terms of efficiency, gas chromatography is more effective and produced more precise result than HPLC when used to quantify chemical constituents in plant extract. Gas chromatography also has its drawback in which the compounds being analysed must be volatile and thermally stable.

Many chemical constituents were found in the *J. gendarussa* extract by the mentioned techniques. The chemical constituents found were phenols, kaempferol, naringenin, tannins, anthocyanins, vitexin, carotenoids, saponins, apigenin, anthraquinons, glycosides, betacyanin, amino acids, and fatty acid.

Over the years, many studies have been done on *J. gendarussa*. However further identification of the phytochemicals present in the extract should be carried out using other methods of detection. Another aspect that should be given attention to is quantification of the chemical constituents in the plant extract.

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REVIEW ARTICLE

Phytochemical analysis and antioxidant activity of different extracts of *Lawsonia inermis*: A mini review

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Abstract:

Lawsonia inermis is a member of the Lythraceae family and is known as "Hinai" in Malaysia and "Henna" in India. It has many traditional medicinal and pharmaceutical properties. The extraction method and solvent determine the extraction yield and antioxidant activity from plants. Thus, the purpose of this review is to provide an overview on how different extraction solvents affect the phytochemical and antioxidant properties of *L. inermis*. The phytochemical constituents recorded in qualitative studies include carbohydrate, protein, amino acid, sterols, saponins, alkaloids, tannins, flavonoid, anthraquinones, terpenoids, steroids, phenols, reducing sugar, glycoside, cardioglycosides, and oils. The solvent such as methanol, ethanol, acetone, chloroform, and aqueous are commonly used for plant extraction. Rather than the bark and fruit parts of *L. inermis*, the leaves and flowers were widely used and reported to reveal many phytochemical constituents. Antioxidant activity of *L. inermis* were measured using DPPH (1,1-Diphenyl-2-picrylhydrazyl), FRAP (ferric reducing antioxidant power), and ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid). Methanol and ethyl acetate extractions of *L. inermis* leaves and seeds, respectively, demonstrated the highest antioxidant activity in DPPH and FRAP assays. In conclusion, *L. inermis* extracts have high antioxidant properties and can be useful in both medicine and food industry. Future studies are needed to investigate the most suitable extraction solvents for each part of this valuable plant.

Keywords: Antioxidant, DPPH, FRAP, *Lawsonia inermis*, phytochemical

1. INTRODUCTION

Natural products remain an important source of synthetic medicine and traditional herbal medicine. According to Welz et al. (2018), the use of herbal medicine, as one element of complementary and alternative medicine is increasing worldwide. Traditional treatments, especially medicinal plants, continue to play a crucial role in addressing basic public health needs. In order to meet basic health needs in developing countries, traditional medicinal methods, in particular the use of medicinal plants, remain vital (Karunamoorthi et al., 2013). Herbal medicines in primary healthcare are in high demand both in developed and developing countries due to their large biological and medicinal activities, increased margins of safety and lower costs (Agarwal et al., 2014 as cited in Padma, 2005).

Lawsonia inermis, an Indian medicinal plant, is a perennial shrub native to India, North Africa, Asia, and Australia (Wagini et al., 2015). The genus Lawsonia bears one species, *L. inermis* (also known as Henna, Mhendi, Shudi, Madurang, Mendi, Manghati, Madayantika and Goranti) (Chaudhary et al., 2010; Wagini et al., 2015) till now, having different synonyms as alba and spinosa belonging to family Lythraceae. The scientific classification of *L. inermis* from kingdom until species is stated in Table 1.

Table 1. Scientific classification of *L. inermis*

Classification	Scientific name
Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Myrtales
Family	Lythraceae
Genus	*Lawsonia*
Species	*inermis*

Based on Figure 1, *L. inermis* is a tall shrub or small tree standing 1.8 to 7.6 m tall (6-25ft). The bark is greyish brown, the leaves are dull green and grow opposite each other's stem. The flowers are tiny, about 1 cm long, numerous, fragrant, white, or pink, with four crumbly petals. The fruit is a small round capsule coloured brown. The fruit contains many-seeded with 32-49 seeds per fruit and opens irregularly into four splits at maturity. Seeds are about 3 mm across, numerous, smooth, pyramidal, hard, and thick seed coat with brownish coloration (Triveni et al., 2016). In other studies carried out by Yadav et al. (2013), they believed that *L. inermis* was unarmed when young, but multiple branches of older trees were spine-tipped. Young branches are green in color and quadrangular, which turn red with age. They also stated that the leaves were indicated to be sub-sessile, around 1.5 to 5 cm long, 0.5 to 2 cm wide, greenish brown to dull green, elliptical to widely lanceolate with total margin, short and glabrous petioles and acute or obtuse apex with a tapering base.

Figure 1. *L. inermis* retrieved from Triveni et al. (2016).

L. inermis is now widely grown in the tropics as an ornamental and dye plant (Rani, 2018). According to Hasan et al. (2015), apart from Asian countries using *L. inermis* as a colouring agent in cosmetic products or textile process, the plant also owned wide range of pharmacological activities, safety, and availability. It has been noted that different parts of the *L. inermis* plant are a rich source of various bioactive principles and have been used in traditional medicine (Dasgupta et al., 2002).

It has been established that the hydroalcoholic extract of *L. inermis* possesses antioxidant activities (Ojewunmi et al., 2014). *L. inermis* has been shown to be rich in phenolic antioxidants such as lawsone, flavonoids, tannins and coumarins (Florence et al., 2015; Sadig et al., 2020). The plant has been reported to have antimalarial, antioxidant and antimicrobial properties (El Babili et al., 2013; Ponugoti, 2018 as cited in Afolayan et al., 2016). In addition, inventory of antidiabetic plants in Lagos State, Nigeria revealed that two percent of traditional practitioners have used *L. inermis* leaves in the management of diabetes (Gbolade, 2009).

Many extraction techniques have been utilized to recover antioxidants from plants which include Soxhlet extraction, maceration, supercritical fluid extraction, subcritical water extraction, and ultrasound-assisted extraction (Do et al., 2014). However, extraction yield and antioxidant activity are not only affected by the extraction method but also the solvents used for extraction. Previous studies have used methanol, n-hexane, chloroform, ethanol, acetone, and water as the solvents for extracting bioactive compounds from *L. inermis* for phytochemical and antioxidant analysis and the results varied between each solvent (Nounah et al., 2017; Sadig et al., 2020; Meghmala et al., 2019). Thus, this study aims to review the phytochemical and antioxidant properties of plant extract of *L. inermis* in different types of extraction solvents.

2. DISCUSSION

Solvents such as methanol, n-hexane, chloroform, ethanol, acetone, and water are commonly used in plant extraction. The extraction solvent is also the most common method used to remove phenolic antioxidants, and both extraction yield and extraction activity rely heavily on the solvent. The antioxidant capacity of phenolic compounds is greatly influenced by the solvent polarity used in extraction. Therefore, choosing extraction solvents is essential for complex plant samples. The extraction solvent system is usually selected for the extraction purpose, the polarity of the components involved, the polarity of undesirable components, the overall cost, safety, and environmental issues (Tan et al., 2013 as cited in Wang et al., 2008).

2.1. Phytochemical Analysis of *L. inermis* in Different Extraction Solvents

2.1.1. Methanol extract

Methanol is an alcohol (-OH) group dominant solvent. It is usually used in medicinal plants for extraction to search for bioactive because of its protic polar solvent. Most of the active compounds of plants are soluble in methanol (Felhi et al., 2017). In a study conducted by Sharma and Goel (2018), they use *L. inermis* leaves that were collected in India. It had been reported that the methanol extract of *L. inermis* leaves shown a presence of alkaloids, cardioglycosides, carbohydrate, steroids, phenol and quinones but an absence of flavonoids.

However, Kimbonguila et al. (2019), found that there was no cardioglycosides present but show the presence of flavonoids in the methanolic extract of *L. inermis* leaf and also revealed the presence of different phytochemical constituents in this plant. These differences may occur due to the different methods of determination of flavonoids used. Sharma and Goel (2018) used alkaline test to detect flavonoids and Legal's test to detect cardioglycosides. On the other hand, Kimbonguila et al. (2019), did not state the method used and were claimed to be assessed with standard methods to detect flavonoids and cardioglycosides. In addition, Nesa et al. (2014) studies show the presence of flavonoids, glycosides,

phytosterol, steroids, and tannins in *L. inermis* barks. Based on this finding, it can be concluded that both barks and leaves of *L. inermis* contain flavonoids, glycosides, steroids, and tannins.

2.1.2. Ethanol extract

According to Dai & Mumper (2010), ethanol is considered an excellent polyphenol extraction solvent and is suitable to be consumed by humans. Besides, it is found easier to penetrate the cellular membrane to extract or remove the intracellular ingredients from the plant material. In a study conducted by Jeyaseelan et al. (2012), the flower, leaf, and fruit parts from *L. inermis* show the presence of flavonoids, saponins and tannins in both flower and fruit. However, only flavonoids and tannins were presence in the leaf. This result contrasted with the finding of Rao et al. (2016) as flavonoids, saponins and tannins were presence in leaf. The different regions of plant collection may contribute to this factor as *L. inermis* leaves from both researchers were collected at Sri Lanka and Osmania, respectively. According to Yusuf (2016), the *L. inermis* leaves from India revealed the absence of tannins, which opposites from the finding of both researchers. The presence of flavonoids, saponins and tannins in flower by Rao et al. (2016) are consistent with the finding of Fathima (2018). This finding shows that ethanol can yield a wider phytochemical constituent in a plant, making it the best extraction solvent for *L. inermis*.

2.1.3. Acetone extract

Acetone, a polar molecule, is organic, non-toxic, and extremely flexible, making it an essential solvent for washing, sterilization, extraction, and chemical research activities. In a study conducted by Chowdhury et al. (2014), *L. inermis* leaf extracted with acetone revealed the presence of cardioglycosides, terpenoids, carbohydrates, phenols, quinones, and tannins. In their results, there was no presence of terpenoids. This finding is also supported by Gull et al. (2013), where the leaf of *L. inermis* also shows the presence of cardioglycosides, terpenoids, carbohydrates, phenols, quinones, and tannins. In addition, other phytochemicals such as flavonoids, phlobatanins, steroid, and volatile oil were found in the acetonic leaf extract of *L. inermis* (Rao et al., 2016; Sharma et al., 2009). Based on this finding, it can be concluded that acetone was commonly used in leaves extraction of *L. inermis* and shows the presence of tannins, flavonoids, terpenoids, saponins, cardioglycosides, glycosides, phlobatanins, steroid, phenolic, proteins, quinones, steroids and volatile oil.

2.1.4. Chloroform extract

Chloroform is a colorless, volatile, liquid derivative of trichloromethane with an ether-like odor. Besides, chloroform is known as a non-polar solvent. According to Leela & Singh (2020), the *L. inermis* leaf collected from Nagercoil, India with chloroform extraction revealed the presence of alkaloid, glycoside, cardiac glycoside, terpenoids, diterpenes, lipids, steroid, phytosterol, resin, fixed oil and fats, carboxylic acid, carbohydrate, and starch. In contrast to Florence et al. (2015), the researchers did not specify the location where the leave was collected and claim to collect the samples at different localities in India. Their study on chloroform extraction of *L. inermis* leaves revealed the presence of carbohydrates, coumarins, phenols, phytosterols, proteins, quinones, sterols and terpenoids but the absence of alkaloids and glycosides in the leaves of *L. inermis*. Though the leaf was taken from the same country in India, the location it was collected is different, resulting in varied phytochemical screening. In another study by Chowdhury et al. (2014), the leaves collected in Bangladesh show the presence of cardioglycosides, tannins, carbohydrates, phenol and quinones but an absence of terpenoids.

2.1.5. Aqueous extract

In a previous study conducted by Leela & Singh (2020), the presence of alkaloids, glycosides, cardiac glycosides, terpenoids, diterpenes, lipids, steroid, phytosterol, quinones, carboxylic acids, carbohydrates, phenols, tannins, flavonoids, coumarins, saponin, phlobotannins, proteins, and amino acids was reported in the leaf part of *L. inermis*. In contrast to the study of Meghmala et al. (2019), they revealed that there were only presence of flavonoids, phenols, and steroids. Meanwhile, in another study by Fathima (2018), the flower of *L. inermis* were reported the presence of alkaloids, carbohydrates, flavonoids, tannins, proteins, amino acids, and sterols in the. Based on these findings, flower and leaf part of this plant produced alkaloids, carbohydrates, flavonoids, tannins, proteins, and amino acids. Table 2 summarises the phytochemical screening of *L. inermis* in the different extract solvents.

2.2. Antioxidant Activity of *L. inermis* in Different Extraction Solvents

According to Chaves et al. (2020), there are several methods that can be used to quantify antioxidant activity which can be categorised depending on the mechanism of action used by the compounds to stop chain-breaking reactions. They can be classified into two main categories which are single electron transfer (SET) and hydrogen-atom transfer (HAT. The most used SET techniques include the 2,2-di-phenyl-1-picrylhydrazyl (DPPH radical scavenging capacity assay), ferric reducing (FRAP), Trolox equivalent antioxidant capacity (TEAC or ABTS), copper reduction (CUPRAC), and reducing power assay (RP). The crocin bleaching assay, the total oxyradical scavenging capacity (TOSC), the oxygen radical absorbance capacity (ORAC), and the total peroxyl radical-trapping antioxidant parameter (TRAP) are examples of hydrogen atom transfer reaction assays. The antioxidant activities of different parts of *L. nermis* in the various extraction solvents are summarised in Table 3.

Table 2. Phytochemical screening of *L. inermis* in different extract solvents

Extraction Solvent	Part of Plant	Phytochemicals	References
Methanol	Bark	Flavonoids, glycosides, phytosterol, steroids, and tannins	Nesa et al. (2014)
	Leaves	Alkaloids, cardioglycocides, carbohydrates, steroids, phenol and quinones	Sharma and Goel (2018)
	Leaves	Alkaloids, terpenoids, flavonoids, tannins, phenolic, saponins, fixed oil and fats	Kimbonguila et al. (2019)
Ethanol	Flower	Flavonoids, saponins, and tannins	Jeyaseelan et al. (2012)
	Flower	Flavonoids, saponins, tannins, alkaloids, cardiac glycosides, glycosides, proteins, amino acids, fixed oil, fats, steroids and terpenoids	Fathima (2018)
	Leaves	Flavonoids and tannins	Jeyaseelan et al. (2012)
	Leaves	Flavonoids, saponins, alkaloids, steroids, terpenoids, tannins, cardiac glycosides, glycosides, reducing sugars, phlobatanins, steroids, phenolic, amino acids, proteins, quinones	Rao et al. (2016)
	Leaves	Flavonoids, alkaloids, saponins, terpenoids, and steroids	Yusuf (2016)
	Fruit	Flavonoids, saponins, and tannins	Jeyaseelan et al. (2012)
Acetone	Leaves	Flavonoids, saponins, steroids, volatile oils, tannins, carbohydrates.	Sharma et al. (2009)
	Leaves	Cardioglycosides, terpenoids, carbohydrates, phenols, quinones, and tannins	Gull et al. (2013)
	Leaves	Cardioglycosides, terpenoids, carbohydrates, phenols, quinones, and tannins	Chowdhury et al. (2014)
	Leaves	Tannins, flavonoids, terpenoids, saponins, cardioglycosides, glycosides, phlobatanins, steroid, phenolic, proteins, and quinones	Rao et al. (2016)
Chloroform	Leaves	Cardioglycosides, tannins, carbohydrates, phenol and quinones but an absence of terpenoids	Chowdhury et al. (2014)
	Leaves	Alkaloid, glycoside, cardiac glycoside, terpenoids, diterpenes, lipids, steroid, phytosterol, resin, fixed oil and fats, carboxylic acid, carbohydrate, and starch	Leela & Singh (2020)
	Leaves	Carbohydrates, coumarins, phenols, phytosterols, proteins, quinones, sterols and terpenoids	Florence et al. (2015)
Aqueous	Flower	Alkaloids, carbohydrates, flavonoids, tannins, proteins, amino acids, and sterols	Fathima (2018)
	Leaves	Flavonoids, phenols, and steroids	Meghmala et al. (2019)
	Leaves	Alkaloids, glycosides, cardiac glycosides, terpenoids, diterpenes, lipids, steroid, phytosterol, quinones, carboxylic acids, carbohydrates, phenols, tannins, flavonoids, coumarins, saponin, phlobotannins, proteins, and amino acids	Leela & Singh (2020)

Table 3. Antioxidant activity of *L. inermis* in different extraction solvents

Antioxidant Activity	Part of Plant	Extraction solvent	Results	References
DPPH	Leaves	Hexane	EC_{50} > 200 µg/mL	Hsouna et al. (2011)
		Chloroform	EC_{50} > 200 µg/mL	
		Ethyl acetate	EC_{50} = 4.8 ± 0.2 µg/mL	
		Water	EC_{50} = 7.6 ± 2.1 µg/mL	
	Leaves	Methanol	70.16 %	Radha et al. (2017)
	Leaves	Methanol	71.7 ± 0.02 %	Meghmala et al. (2019)
	Seed	Hexane	IC_{50} > 100 µg/mL	Chaudhary & Kalia (2014)
		Chloroform	IC_{50} > 100 µg/mL	
	Seed	Hexane and chloroform	IC_{50} > 100 µg/mL	Nounah et al. (2017)
	Seed	Hexane	IC_{50} > 100 mg/L	Chaibi et al. (2017)
		Chloroform	IC_{50} > 100 mg/L	
		Methanol	IC_{50} = 4.6 ± 0.2 mg/L	
FRAP	Leaves	Ethyl acetate	IC_{50} = 486 µg/mL	Kumar et al. (2014)
		Butanol	IC_{50} = 504.76 µg/mL	
		Chloroform	IC_{50} = 782.49 µg/mL	
		Methanol	IC_{50} = 900.83 µg/mL	
	Leaves	Methanol	1101 ± 0.02 µg/Trolox equivalent	Meghmala et al. (2019)
	Whole	Aqueous	IC_{50} = 313.93 ± 0.39 µg/mL	Guha et al. (2011)
		Methanol	IC_{50} = 430.8 ± 0.35 µg/mL	
		Chloroform	IC_{50} = 1815.67 ± 0.11µg/mL	
ABTS	Leaves	Ethanol	IC_{50} = 6.9 ± 0.1 mg/L	El Babili et al. (2013)
		Petroleum ether	IC_{50} = 738.7 ± 9.6 mg/L	
		Ethyl acetate	IC_{50} = 8.6 ± 0.2 mg/L	
	Leaves	Ethanol	IC_{50} = 1.29 µg/mL	Kumar et al. (2014)
		Methanol	IC_{50} = 1.43 µg/mL	
		Butanol	IC_{50} = 2.90 µg/mL	
		Chloroform	IC_{50} = 27.24 µg/mL	
		Hexane	IC_{50} = 174.3 µg/mL	
		Aqueous	IC_{50} = 219.47 µg/mL	
	Seed	Methanol	IC_{50} = 3 ± 1.3 mg/L	Chaibi et al. (2017)
		Chloroform	IC_{50} > 100 mg/L	
		Hexane	IC_{50} > 100 mg/L	
	Seed	Hexane	IC_{50} = 1283.8 ± 7.4 µg/mL	Nounah et al. (2017)

2.2.1. DPPH scavenging activity

1,1-Diphenyl-2-picrylhydrazyl (DPPH) assay is a fast, easy, and economical colorimetric test to measure antioxidants' ability to reduce the DPPH radical. DPPH is widely used to measure the ability of compounds to serve as scavengers of free radicals and to determine foods' antioxidant activity. In antioxidant activity studies of plant extracts, the DPPH approach has been widely used (Chaves et al., 2020). In addition, this activity was also calculated by evaluating the IC_{50} or EC_{50} values corresponding to the concentration of sample needed to scavenge 50 percent of the sum of the initial DPPH radicals in the mixture of the reaction. The higher the IC_{50} or EC_{50} value, the lower the antioxidant activity of the sample tested (Hsouna et al., 2011; Dhaouadi et al., 2015).

According to Meghmala et al. (2019), methanolic extract of *L. inermis* leaf showed to have antioxidant properties when tested with DPPH scavenging activity which resulted in 71.7 ± 0.02 % DPPH scavenged. This finding is also supported by Radha et al. (2017), where the antioxidant scavenging activity for the leaf part in methanolic extract of *L. inermis* resulted in 70.16 %. In their results, 50 mL of extract sample can produce scavenging activity of 44.20 %. This shows that the methanolic extract of *L. inermis* leaves contain higher antioxidant activity even in low concentration which, according to the researcher, may occur due to higher total phenolic content. On the other hand, a study conducted by Hsouna et al. (2011), values of EC_{50} in the DPPH free radical-scavenging of *L. inermis* leaf extracted with hexane, chloroform, ethyl acetate, and water shows $EC_{50} > 200$ µg/mL, $EC_{50} > 200$ µg/mL, $EC_{50} = 4.8 \pm 0.2$ µg/mL, and $EC_{50} = 7.6 \pm 2.1$ µg/mL, respectively. This finding suggested that hexane and chloroform are not the best extraction solvent for observing the antioxidant activity of *L. inermis* because both solvents did not show any antioxidant activities.

Another study conducted by Chaibi et al. (2017), values of IC_{50} in the DPPH free radical scavenging of *L. inermis* seed extracted with hexane, chloroform, and methanol are $IC_{50} >$ 100 mg/L, $IC_{50} >$ 100 mg/L, and $IC_{50} = 4.6 \pm 0.2$ mg/L, respectively. Studies conducted by Chaudhary & Kalia (2014) and Nounah et al. (2017) show that antioxidant activity of chloroform and hexane for seed extraction of *L. inermis* display the IC_{50} value more than 100 µg/mL. Based on this finding, it can be concluded that methanol is a better solvent than other solvents for a more consistent extraction of antioxidants from *L. inermis* leave and seeds.

2.2.2. Ferric reducing antioxidant power

The ferric reducing antioxidant power (FRAP) assay is based on the potential of samples to reduce Fe^{3+} to Fe^{2+} (Spiegel et al., 2020). According to Meghmala et al. (2019), the absorbance of Soxhlet methanol of leaf extract at 593nm was shown a higher antioxidant potential than aqueous and Soxhlet water extracts. For *L. inermis* leaf in Soxhlet methanol extraction, 1101 ± 0.02 µg per trolox equivalent were reported. However, aqueous extract of *L. inermis* leaf, was shown to have the lowest reducing power with 400.66 ± 0.04 µg per trolox equivalent. This finding is also supported by Kumar et al. (2014), where methanol extraction of *L. inermis* leaf was also reported to have higher reducing power than water extraction. However, according to Kumar et al. (2014), ethyl acetate (IC_{50} = 486 µg/mL) was found to have the greatest reduction power followed by butanol (IC_{50} = 504.76 µg/mL), chloroform (IC_{50} = 782.49 µg/mL), and methanol (IC_{50} = 900.83 µg/mL). Hexane and aqueous were found to be least active when compared to the rutin equivalent and both solvents did not attain 50 % inhibition even at the maximum concentration measured. In contrast with the study of Guha et al. (2011), the use of a whole plant of *L. inermis* was extracted using a Soxhlet apparatus. In their study, *L. inermis* plant in aqueous extraction shown the highest activity (IC_{50} = 313.93 ± 0.39 µg/mL) compared to methanol (IC_{50} = 430.8 ± 0.35 µg/mL) and chloroform with the least antioxidant efficiency (IC_{50} = 1815.67 ± 0.11µg/mL). These differences may be due to different phenolic compounds distribution in different parts of the plant, directly contributing to antioxidant action.

In another study conducted by Chaudhary & Kalia (2014), the results showed for 50 µg/ml of *L. inermis* seed sample that out of different extract, the absorbance of ethyl acetate (0.165) showed the highest reducing power followed by ethanol (0.144), aqueous (0.094) and chloroform (0.042). This finding is supported by Philip et al. (2011), the absorbance of ethanol extract of *L. inermis* seed was shown higher reducing power than aqueous extract. In the same study, petroleum ether extract of *L. inermis* seed revealed the lowest reducing power compared to ethanol and aqueous extract. It is important to note that both Chaudhary & Kalia (2014) and Philip et al. (2011) used ascorbic acid as reference standards. The reducing capacity of a compound can serve as the antioxidant activity, with the reducing power of extracts are directly proportional with extract concentration. Increased absorption of the reaction mix means an increase in the sample reduction power. Based on this finding, it can be concluded that in FRAP assay, ethyl acetate is the best extraction solvent for leaf and seed of *L. inermis*. The successful reduction of the extract of ethyl acetate demonstrates its efficacy in preventing oxidation. Naturally occurring reductants are active in the processes of oxidative protection, and reduction ability may serve as an essential indicator of their potential antioxidants.

2.2.3. ABTS scavenging activity

The 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid (ABTS) assay is also commonly used to assess the antioxidant potential of natural products. According to El Babili et al. (2013), the study on extraction yields and antioxidant activity of *L. inermis* leaf was investigated *in vitro*. The ethanol extract of *L. inermis* leaf showed an antioxidant activity IC_{50} of 6.9 ± 0.1 mg/L. The least antioxidant extract with IC_{50} was petroleum ether extract with 738.7 ± 9.6 mg/L. The ethyl acetate extract exhibited an IC_{50} of 8.6 ± 0.2 mg/L. This

finding showed that ethanol extracts yield the highest antioxidant for the leaf part of *L. inermis* in ABTS assay compared to other solvents used in the study. This result was in line with Kumar et al. (2014) where all extracts and fractions of *L. inermis* leaf demonstrated the ability to scavenge ABTS radicals and the highest antioxidant activity was shown in the ethanolic extracts.Their activity based on IC_{50} values was in the order: ethanol (IC_{50} = 1.29 µg/mL) > methanol (IC_{50} = 1.43 µg/mL) > butanol (IC_{50} = 2.90 µg/mL) > chloroform (IC_{50} = 27.24 µg/mL) > hexane (IC_{50} = 174.3 µg/mL) > aqueous (IC_{50} = 219.47 µg/mL). Based on this finding, in ABTS assay, ethanol solvent could be the best for measuring antioxidant activity for the leaf part of *L. inermis*.

In another research by Chaibi et al. (2017), the seed extracts of *L. inermis* were tested for antioxidant activity by individual seed. The antioxidant activity of seed extracts according to the ABTS assay was more significant by methanol (IC_{50} = 3 ± 1.3 mg/L). Extracts of chloroform and hexane display no antioxidant activity (IC_{50} > 100 mg/L), which corresponded to the result of Nounah et al. (2017), where the anti-radical activity of *L. inermis* seed oil extracted by hexane exhibited a very weak antioxidant activity (IC_{50} = 1283.8 ± 7.4 µg/mL). Even though it is a mixture of several compounds, the IC_{50} is comparable to the vitamin C of ABTS (IC_{50} = 3 ± 1.6 mg/L) (Chaibi et al., 2017). They proposed that the high levels of total phenolics in polar extracts were primarily responsible for the antioxidant activity of *L. inermis*. Based on this finding, it can be concluded that different parts of *L. inermis* may require a different solvent to observe better antioxidant properties in ABTS assay. This variation might be due to the different polarities of the different compounds in the plant extracts.

3. CONCLUSION

In conclusion, the extraction solvents play an important role in the extraction of bioactive groups from *L. inermis*. Solvent attracts various plant compounds based on several variables, such as polarity, boiling temperature, heat, oxygen and light reactivity, viscosity, and stability. Methanol, ethanol, and ethyl acetate are commonly suggested as acceptable extraction solvent for antioxidant assays such as DPPH, FRAP and ABTS. Many phytochemical constituents of antioxidant potential have been identified for all parts of the *L. inermis*, including leaves, barks, flowers, and seeds. Therefore, *L. inermis* has a significant advantage in treating diseases since it has many phytochemical components and antioxidant abilities. Future studies are required to identify the most suitable extraction solvents for each part of this valuable plant.

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RESEARCH ARTICLE

Nighttime exercise, sleep quality and Salah concentration of adult Muslims in Johor

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Abstract:

Exercise is a subcategory of physical activity which is structured, repetitive and purposeful. This study focuses on only one of the pillars of Islam, which is to perform the salah (prayer). Various research studies measure exercise with sleep outcome but none of the study focus on its relation to religious practice, thus how nighttime exercise affect sleep quality and its relation to religious practices of Muslim is yet to be known. A cross-sectional study using an online questionnaire was implemented to identify how nighttime exercise affect sleep quality and its relationship with religious practices among Muslim focusing on concentration in prayer or salah (fajr) which was done at the dawn by Muslims. A total of 176 Muslims young adults participated in this research. Overall, the results found that different types of night exercise intensity influence the ability of respondents to wake up early for fajr ($p=0.005$). In fact, poor sleep quality gives a significant impact to concentration in prayer (fajr) ($p<0.05$). However, poor sleep quality was not affected by different age intervals, duration and frequency, and type of night exercise intensity. Future study should focus on awareness of sleep hygiene among Muslims as in this study poor sleep quality was proven to give an impact. Moreover, future study needs to consider other reasons that contribute to their trouble sleeping despite doing nighttime exercise. For example, how religious the respondents are also can be considered as one the variables that may affect both abilities to wake up early for fajr and concentration in salah (fajr) following nighttime exercise.

Keywords: Muslim, night exercise, sleep quality, salah concentration, young adult

1. INTRODUCTION

Awtry and Balady (2010) mentioned that exercise intensity is referring to amount of energy required to perform physical activity per unit of time or resting oxygen requirement (metabolic equivalents [METs]), where one MET equals the amount of oxygen consumed by a resting, awake individual and is equivalent to 3.5 ml O2/kg of body weight/minute. Light exercise includes those activities requiring less than 3 METs such as brisk walking and bowling, moderate activity includes activities requiring 3 to 6 METs for example fast walking, badminton and tennis, while vigorous activity includes activities requiring more than 6 METs such as running and jogging, long distance cycling, football and basketball (Awtry & Balady, 2010). Above all, exercise is associated with various benefits that help individuals to function effectively and boost their emotions to feel good and thus by being physically fit, it gives advantage to an individual's overall health (Abou Elmagd, 2016). Nighttime exercise is brought into focus in this study as the current fitness trend in Malaysia is that most Malaysians like to exercise during night.

Despite the sleep hygiene recommendations, where intensive exercising is not suggested within the last 3 hour before bedtime (Petruzzello et al., 1991 in Myllymäki et al., 2011), there are still people who exercise late at night as time restricts them from exercising during the day, maybe due to work, study and any other factors. Sleep hygiene was described as habits and behaviors besides the environment that help in promoting sleep. Based on a study of effects of vigorous late-night exercise on sleep quality and cardiac autonomic activity by Myllymäki et al. (2011), individuals have less actual sleep time (min) and shortened sleep onset latency after exercise day than control day without exercise but have more sleep efficiency (%) where they have a greater proportion of non-REM sleep after exercise day than control day without exercise. Meanwhile, according to Oda et al. (2014), doing vigorous exercise before going to bed can cause a large physiologic excitement at bedtime hence might disrupt the onset of sleep and might affect overall sleep time of a person. Yamanaka et al. (2015) stated that physical exercise in the evening was reported to deteriorate sleep structure by increasing arousal and inadequate sleep hygiene besides heart rate increased and relaxation time decreased in subsequent sleep after evening exercise. Seo et al. (2013) revealed that exercise does give different effects or outcomes, based on the exercise type, duration, and hormone adaptation depending on time of the day exercise takes place. This was supported by a study done by Stutz et al. (2019) that mentioned although sleep-onset latency, total sleep time, and sleep efficiency (SE) might be impaired after vigorous exercise ending ≤ 1 hour before bedtime, exercise performed in the evening does not seem to negatively affect sleep but in fact, rather the opposite where the effects are small as several factors related to

physical exercise have been proposed to improve sleep, including an increase in body temperature before bedtime, enhanced vagal modulation, changes in cortisol and growth hormone secretion, and improved mood. The differences on the conclusion or results from previous study urge this study aimed to seek an answer on how and in what way nighttime exercise will affects sleep quality specifically among Malay young adults who need to wake up early for fajr every day and whether by doing nighttime exercise will affect their ability to wake up early for fajr.

This study focuses on only one of the pillars of Islam, which is to perform the salah (prayer). Bahammam & Gozal (2012) point out that Muslim population are strongly encouraged to go to bed early and waking in Islamic culture as they are required to wake up early to pray (Fajr) at dawn. However, only a proportion of Muslims follow prayer times strictly and wake up early on weekdays and weekends for dawn prayer (Bahammam & Gozal, 2012) although they are obligated to do so. Prayer is a major duty in life for a Muslim. Yusni et al. (2019) mentioned that the sharia or Islamic law dictating the prayers performed five times every day is obligatory and leaving it is sinful as declared in al Quran "Verily, Salah is an obligation on the believers to be observed at its appointed time." (Qur'an 4:103).

This study also aimed at raising awareness about good sleep habits, indirectly improving sleep diagnosis and treatment, as well as knowing whether nighttime exercise is suitable and recommended for Muslim, as nighttime exercise might affect their sleep quality hence may give impact on their religious practice in term of prayer, as in being able to wake up early in the next morning to pray for fajr following nighttime exercise and their concentration in prayer (khusyu'). Nevertheless, the relationship between nighttime exercise and sleep quality and the way it provides impact to religious practices of Muslim will be discussed in this study.

2. MATERIALS AND METHODS

For this research purpose, a cross sectional study was implemented by using an online questionnaire that was distributed among adults that live in Johor. Data was collected and then analyzed by using SPSS 20.0. This cross-sectional study was conducted at Johor involving Malay adults that are actively engaged in nighttime exercise in all ten districts of Johor which are Batu Pahat, Johor Bahru, Kluang, Kota Tinggi, Kulaijaya, Mersing, Muar, Pontian, Segamat and Tangkak. Malay adults with ages ranging from 20-44 years old were chosen as the target population as these age groups of adults are believed to be the most physically active compared to other age groups. Other than that, Malay ethnic have the least prevalence of physical inactivity among respondents aged 16 years and above in Malaysia by socio-demographic characteristics as stated by National Health and Morbidity Survey 2019. (NHSM, 2019). Convenience sampling was applied in this study.

Inclusion criteria for respondents includes those aged 20 to 44 years old, Malay, Muslims, live in Johor, understand basic English, exercise at night regularly and do not have sleeping disorders. While respondents who have other medical conditions that may affect sleep quality for example kidney disease, thyroid disease, diabetes, and mental health disorder like depression were excluded from the study.

The questionnaire for this study contains four sections: Section A, which contains demographic data, Section B, which contains The Godin Leisure-Time Exercise Questionnaire (GLTEQ), Section C, which contains Pittsburgh Sleep Quality Index (PSQI) questionnaire and Section D, which contains Salah Flow Questionnaire (Focused Attention). In the demographic data, information about research including the intent of research, medium available to reach out researchers regarding research and the level of commitment required from participants is made available. Consent form was provided where the respondents need to agree on information relating with participant anonymity and participant confidentiality before respondents are required to fill in basic information about age, gender and religion. From The Godin Leisure-Time Exercise Questionnaire (GLTEQ), data relating to intensity and frequency of night exercise will be obtained. In order to know the exact nighttime exercise duration of the respondent, an additional question regarding duration of exercise per day will be added. 'How long do you exercise per day?' will be rated by respondents in minutes. To measure the quality and patterns of sleep, Pittsburgh Sleep Quality Index (PSQI) which are standardized, and self-report assessment were utilized.

As there are no methods for measurement that can assess the level of concentration (khusyu') during salah (prayer), an adapted questionnaire was developed from Salah Flow Questionnaire (SFQ), by Wael Abouelsaadat in his thesis submitted into Department of Computer Science, University of Toronto in 2012. With only 6 questions of focused attention items used to measure salah concentration taken from SFQ, a pilot study was conducted to establish the reliability of this instrument before actual data collection was started. The items include 'During Salah, I often have to repeat a Sura or Tahiyat because I feel I recited it mechanically.', After Salah, I am sometimes not sure about the actual number of steps I made.', 'After Salah, I sometimes feel guilty due to my performance.', I have to repeat a Salah after performing it because I feel it was not performed adequately.', 'I often make mistakes during Salah.', and lastly 'I am satisfied with my concentration level during Salah'. By applying rule of thumb by Browne (1995), a minimum of 30 respondents was needed for this questionnaire pilot study as Whitehead et al. (2016) mentioned that the simplest methods to apply are sample size rules of thumb when we want to estimate the sample size for the pilot trial. Pilot testing done for Salah Concentration Questionnaires yielded acceptable reliability of 6 items in the questionnaire was found by using Cronbach Alpha (α=0.733) with a mild negative corrected item total correlation (p= -0.255) of item 6 which indicates that those with poor performance in prayer (fajr) are more likely satisfied with their concentration in prayer at the initial reliability testing using SPSS. Therefore item 6 was removed from the questionnaire to increase the reliability or internal consistency of the questionnaire and hence produce good internal consistency (α=0.890).

Aiming proper main data collection through online or digital platforms, questionnaires were distributed to various social media and social networks. In order to collect data more efficiently, questionnaires were distributed to gyms or fitness centres available around Johor too through email or any other online medium available to contact them. The respondents that fit in inclusion criteria would complete the questionnaire upon giving consent. The involvement of the respondents is based on their consent, without any pressure. Data from respondents were saved in the form of excel and later were analysed by using SPSS 20.0.

Measurement scale for each data was identified to determine the best statistical analysis to be applied in order to analyse data for each research question. Chi square was applied for all the research questions in this study as all of the data is categorical data.

3. RESULTS

There was a total of N=176 respondents, with N = 61 (34.7%) belonging to male and N = 115 (65.3%) belonging to females. The age of respondents was divided into five ranges which includes 20 to 24 years old with N = 126 (71.6%), 25 to 29 years old with N = 30 (17%), 30 to 34 years old with N = 13 (7.4%), 35 to 39 years old with N = 5 (2.8%) and lastly 40 to 44 years old with N = 2 (1.1%). Most importantly, all of the respondents is Muslim, N = 176 (100%) as required in inclusion criteria of this study.

Table 1: Frequency and percentage of respondent's age

Variable	Frequency (N)	Percent (%)
Age Range		
20-24 years old	126	71.6
25-29 years old	30	17
30-34 years old	13	7.4
35-39 years old	5	2.8
40-44 years old	2	1.1
Total	176	100.0

The respondents most often will do nighttime exercise in approximately 15 to 30 minutes per exercise session with n=89 (50.6%) followed by 35 (19.9%) of respondents will do exercise during the night between 46 to 60 min per daily basis. There are 33 (18.8%) respondents that will do nighttime exercise in less than 15 minutes per day. Other than that, 13 (7.4%) of the respondents will perform nighttime exercise for more than 60 minutes on average in an exercise session followed by 6 (3.4%) respondents who do nighttime exercise for 31 to 45 minutes per session.

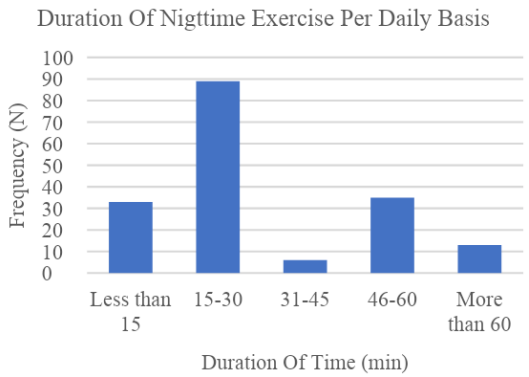

Figure 1: Duration of nighttime exercise done by respondent per daily basis

Type of intensity of nighttime exercise done by respondents on average was determined by the highest frequency type of intensity of the individual exercise. About 72 (26.1%) respondents did strenuous exercise while 40 (14.5%) and 64 (23.2%) respondents did moderate and light exercise weekly.

Table 2: Type of night exercise intensity

Types of Exercise Intensity	Frequency N (%)
Strenuous Exercise	72 (41.0%)
Moderate Exercise	40 (23.0%)
Mid/ Light Exercise	64 (36.0%)

Meanwhile, out of 176 respondents who do nighttime exercise regularly, 78 (44.3%) of them have good sleep quality while 98 (55.7%) of the respondents have poor sleep quality. Ability of respondents to wake up for fajr following nighttime exercise was also asked in the questionnaire. From the 176 responses, it was found that 36 (20.5%) of the respondents were unable to wake up for fajr following nighttime exercise. On the contrary, 140 (79.5%) respondents were able to do so.

Following the ability to wake up for fajr after doing nighttime exercise, an important part of the prayer or salah which is concentration was taken into consideration. From the assessment, it was found that respondents agree on the first item in the Salah Concentration Questionnaire 'During Salah, I often have to repeat a Sura or Tahiyat because I feel I recited it mechanically' marked by 40 (22.7%) and 12 (6.8%)

respondents that agree and strongly agree with the first statement given. For the second item which is 'After Salah, I am sometimes not sure about the actual number of steps I made.' about 59 (33.5%) respondents neither agree nor disagree that sometimes they are not sure about the actual number of steps that they made. About 59 (33.5%) respondents do agree that sometimes they feel guilty due to their performance in Salah following nighttime exercise supported by 28 (15.9%) respondents who strongly agree with the statement. For the third to fifth item, most respondents prefer to stay neutral indicating that they did not agree or disagree with the statements.

Table 3: Salah concentration following nighttime exercise

Salah Concentration Questionnaire	Responses, N (%)					Mean (Standard Deviation) M(SD)
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	
Item 1	12 (6.8)	40 (22.7)	58 (33.0)	43 (24.4)	23 (13.1)	2.858 (1.120)
Item 2	14 (8.0)	43 (24.4)	59 (33.5)	41 (23.3)	19 (10.8)	2.955 (1.110)
Item 3	28 (15.9)	59 (33.5)	55 (31.3)	22 (12.5)	12 (6.8)	3.392 (1.106)
Item 4	10 (5.7)	27 (15.3)	66 (37.5)	49 (27.8)	24 (13.6)	2.716 (1.063)
Item 5	8 (4.5)	30 (17.0)	77 (43.8)	45 (25.6)	16 (9.1)	2.824 (0.973)

Level of agreement in Salah Concentration Questionnaire was input as '5' for strongly agree, '4' for agree, '3' for neutral, '2' for disagree and '1' for strongly disagree in SPSS software. Based on Table 3, all items are above average in mean score (M>2.500) indicates that respondents' salah concentration was affected. Item 3 has the highest mean score (M=3.392, SD=1.106) indicating that most respondents almost agree that sometimes they felt guilty due to their performance in prayer (fajr) following nighttime exercise. On the other hand, the item with the lowest mean score from the questionnaire is item 4 which is 'I have to repeat a Salah after performing it because I feel it was not performed adequately.' with (M =3.248, SD =1.063) where least respondents felt that they have to repeat the Salah after performing it.

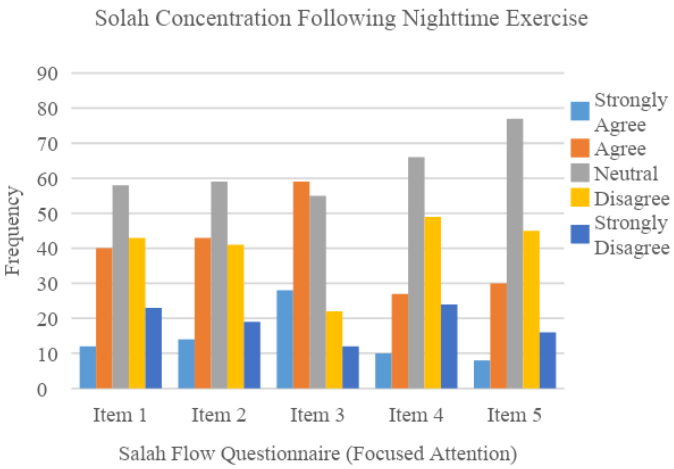

Figure 2: Salah concentration following nighttime exercise

3.1. Sleep Quality and Age Interval

The relationship between each variable as in objectives of this study was done by using chi square test. For the first objective, which is to identify differences in sleep quality of individuals who do nighttime exercise at different age intervals, it was found that there was no significant association between sleep quality and different age intervals with p-value of 0.156 (p>0.05).

Table 4: Association between sleep quality and age interval

Age (Years old)	Sleep Quality N (%)		X^2 statistic (df)	P-value
	Good	Poor		
20-24	51 (65.4)	75 (76.5)	6.641 (4)	0.156
25-29	14 (17.9)	16 (16.3)		
30-34	9 (11.5)	4 (4.1)		
35-39	2 (2.6)	3 (3.1)		
40-44	2 (2.6)	0 (0.0)		

3.2. Frequency and Duration of Night Exercise and Sleep Quality

For the second objective, it was found that there is no significant association between duration and frequency of night exercise and sleep quality with p-value of 0.131

(p>0.05) hence, from the data analysis we can conclude that duration and average frequency of night exercise does not affect sleep quality.

Table 5: Association between duration and frequency of night exercise and sleep quality

Sleep Quality	Average Frequency of Exercise (day) N (%)								X^2 (df)	P-value
	Duration of exercise (min)	1	2	3	4	5	6	7		
Good	Less than 15	8 (4.5)	5 (2.8)	3 (1.7)	1 (0.6)	0 (0)	0 (0)	0 (0)	31.860 (24)	0.131
	15-30	13 (7.4)	21 (11.9)	8 (4.5)	10 (5.7)	2 (1.1)	1 (0.6)	0 (0)		
	31-45	0 (0)	3 (1.7)	1 (0.6)	0 (0)	0 (0)	0 (0)	0 (0)		
	46-60	2 (1.1)	9 (5.1)	3 (1.7)	2 (1.1)	0 (0)	0 (0)	0 (0)		
	More than 60	0 (0)	1 (0.6)	1 (0.6)	2 (1.1)	1 (0.6)	1 (0.6)	0 (0)		
Poor	Less than 15	4 (2.3)	9 (5.1)	3 (1.7)	0 (0)	0 (0)	0 (0)	0 (0)		
	15-30	9 (5.1)	10 (5.7)	9 (5.1)	4 (2.3)	2 (1.1)	0 (0)	0 (0)		
	31-45	1 (0.6)	0 (0)	1 (0.6)	0 (0)	0 (0)	0 (0)	0 (0)		
	46-60	2 (1.1)	9 (5.1)	5 (0)	0 (0)	0 (0)	2 (1.1)	1 (0.6)		
	More than 60	1 (0.6)	4 (2.3)	0 (0)	2 (1.1)	0 (0)	0 (0)	0 (0)		

3.3. Types of Night Exercise Intensity and Sleep Quality

No significant association between type of intensity of night exercise and sleep quality with p-value of 0.097 (p>0.05) although 34 (19.3%) respondents have poor sleep quality following strenuous exercise whereas most respondents who have poor sleep quality are individuals who do light exercise, N=42 (23.9%). Therefore, as the type of intensity of night exercise that does not affect sleep quality, the type of intensity of nighttime exercise that gives more impact on sleep quality was unable to be determined.

Table 6: Association between type of intensity of night exercise and sleep quality

Types of Intensity of Exercise	Sleep Quality N (%)		X^2 statistic (df)	P-value
	Good	Poor		
Strenuous	38 (21.6)	34 (19.3)	4.660 (2)	0.097
Moderate	18 (10.2)	22 (12.5)		
Light	22 (12.5)	42 (23.9)		
Total	78 (44.3)	98 (55.7)		

3.4. Ability to Wake Up Early for Fajr Following Nighttime Exercise

For the fourth objective of this study, it was revealed that there is significant association between engagement in nighttime exercise and ability to wake up early for fajr with a p-value of 0.001 (p<0.05). Strenuous type of night exercise was found to be the type of night exercise intensity that affects 20 (11.4%) respondents' ability to wake up early for fajr with p-value of 0.005 (p<0.05). Meanwhile, sleep quality was found to have no association with ability to wake up early (p=0.462). Hence, we can conclude that doing nighttime exercise does affect Muslims ability to wake up early for fajr.

Table 7: Association between engagement in nighttime exercise and ability to wake up early for fajr

Engagement In Nighttime Exercise	Ability To Wake Up For Fajr N (%)		X^2 statistic (df)	P-value
	Yes	No		
Yes	140 (79.5)	36 (20.5)	61.455 (1)	0.001
No	0 (0)	0 (0)		

Table 8: Association between ability to wake up for fajr with type of intensity of night exercise

Type Of Exercise Intensity	Ability To Wake Up For Fajr N (%)		X^2 statistic (df)	P-value
	Yes	No		
Strenuous	52 (29.5)	20 (11.4)	10.648 (2)	0.005
Moderate	39 (22.2)	1 (0.6)		
Light	49 (27.8)	15 (8.5)		

Table 9:Aassociation between sleep quality and ability to wake up early for fajr

Sleep Quality	Ability to wake up for fajr N (%)		X^2 statistic (df)	P-value
	Yes	No		
Good	64 (36.4)	22 (12.5)	0.541 (1)	0.462
Poor	76 (43.2)	14 (8.0)		

3.5. Salah Concentration Following Nighttime Exercise

The last objective in this study is to identify the relationship between concentration in prayer (fajr) and nighttime exercise. As Salah Concentration Questionnaire has no specific scoring, each item in the questionnaire was correlated with sleep quality of respondents who do nighttime exercise. It was found that there is significant association between both variables with a p-value of 0.029, 0.014 and 0.026 ($p<0.05$) for item 1, 2 and 3 respectively. However, there was no significant association found between the types of intensity of night exercise in relation with Salah concentration. Hence, we can conclude that nighttime exercise does not give an impact to concentration in prayer (fajr) although there is significant association between salah concentration and sleep quality. This is due to frequency, duration and type of intensity of night exercise does not impact sleep quality of respondents who engage in nighttime exercise.

Table 10: Association between Salah concentration and sleep quality of respondents who engage in nighttime exercise

Salah Concentration		Sleep Quality N (%)		X^2 statistic (df)	P-value
		Good	Poor		
Item 1	Strongly Agree	4 (2.3)	8 (4.5)	10.772 (4)	0.029
	Agree	10 (5.7)	30 (17.0)		
	Neutral	27 (15.3)	31 (17.6)		
	Disagree	23 (13.1)	20 (11.4)		
	Strongly Disagree	14 (8.0)	9 (5.1)		
Item 2	Strongly Agree	4 (2.3)	10 (5.7)	12.524 (4)	0.014
	Agree	13 (7.4)	30 (17.0)		
	Neutral	24 (13.6)	35 (19.9)		
	Disagree	25 (14.2)	16 (9.1)		
	Strongly Disagree	12 (6.8)	7 (4.0)		
Item 3	Strongly Agree	6 (3.4)	22 (12.5)	11.056 (4)	0.026
	Agree	28 (15.9)	31 (17.6)		
	Neutral	26 (14.8)	29 (16.5)		
	Disagree	9 (5.1)	13 (7.4)		
	Strongly Disagree	9 (5.1)	3 (1.7)		
Item 4	Strongly Agree	2 (1.1)	8 (4.5)	5.929 (4)	0.204
	Agree	12 (6.8)	15 (8.5)		
	Neutral	27 (15.3)	39 (22.2)		

	Disagree	22 (12.5)	27 (15.3)		
	Strongly Disagree	15 (8.5)	9 (5.1)		
Item 5	Strongly Agree	1 (0.6)	7 (4.0)	7.045 (4)	0.134
	Agree	11 (6.3)	19 (10.8)		
	Neutral	33 (18.8)	44 (25)		
	Disagree	23 (13.1)	22 (12.5)		
	Strongly Disagree	10 (5.7)	6 (3.4)		

Table 11: Association between type of night exercise intensity and Salah concentration

Salah Concentration		Type of Exercise Intensity N (%)			X^2 statistic (df)	P-value
		Strenuous	Moderate	Light		
Item 1	Strongly Agree	8 (4.5)	3 (1.7)	1 (0.6)	9.240 (8)	0.322
	Agree	17 (9.7)	11 (6.3)	12 (6.8)		
	Neutral	20 (11.4)	12 (6.8)	26 (14.8)		
	Disagree	15 (8.5)	10 (5.7)	18 (10.2)		
	Strongly Disagree	12 (6.80	4 (2.3)	7 (4.0)		
Item 2	Strongly Agree	7 (4.0)	4 (2.3)	3 (0.6)	5.229 (8)	0.733
	Agree	21 (11.9)	11 (6.3)	11 (6.3)		
	Neutral	22 (12.5)	12 (6.8)	25 (14.2)		
	Disagree	15 (8.5)	9 (5.1)	17 (9.7)		
	Strongly Disagree	7 (4.0)	4 (2.3)	8 (4.5)		
Item 3	Strongly Agree	9 (5.1)	7 (4.0)	12 (6.8)	4.097 (8)	0.848
	Agree	26 (14.8)	15 (8.5)	18 (10.2)		
	Neutral	22 (12.5)	10 (5.7)	23 (13.1)		
	Disagree	10 (5.7)	4 (2.3)	8 (4.5)		
	Strongly Disagree	5 (2.8)	4 (2.3)	3 (0.6)		
Item 4	Strongly Agree	6 (3.4)	0 (0)	4 (2.3)	5.402 (8)	0.714
	Agree	11 (6.3)	8 (4.5)	8 (4.5)		
	Neutral	28 (15.9)	15 (8.5)	23 (13.1)		
	Disagree	19	10 (5.7)	20 (11.4)		
	Strongly Disagree	8 (4.5)	7 (4.0)	9 (5.1)		
Item 5	Strongly Agree	6 (3.4)	1 (0.6)	1 (0.6)	6.991 (8)	0.538
	Agree	11 (6.3)	10 (5.7)	9 (5.1)		
	Neutral	31 (17.6)	15 (8.5)	31 (17.6)		
	Disagree	17 (9.7)	10 (5.7)	18 (10.2)		
	Strongly Disagree	7 (4.0)	4 (2.3)	5 (2.8)		

Result shows that there is no significant association between age interval, frequency and duration of exercise, other than type of exercise intensity when compared to sleep quality with p-value of 0.156, 0.131 and 0.097 respectively. There is a significant association between engagement in nighttime exercise and the ability to wake up early for fajr (p=0.001) besides association between types of intensity of night exercise and the ability to wake up early for fajr (p=0.005). However, no significant association was found between sleep quality and ability of respondents to wake up

early for fajr (p=0.462). Significant association was found between salah concentration with sleep quality of respondents who do nighttime exercise with p values of 0.029, 0.014 and 0.026 ($p<0.05$) for item 1, 2 and 3 respectively. However, the type of intensity of night exercise was found to have no significant association with salah concentration. Therefore, we can conclude that nighttime exercise does not influence concentration in salah (fajr) as frequency, duration and type of intensity of night exercise does not impact sleep quality of respondents who engage in nighttime exercise. Nevertheless, sleep quality was proven to influence concentration in prayer.

3.5. Discussion

Madrid-Valero et al. (2017) mentioned that there is a direct relationship between age and deterioration in the quality of sleep. In contrast, this study revealed that the age interval of individuals who do nighttime exercise does not have an impact on sleep quality. Veqar and Hussein (2012) also mentioned that exercise is a positive behavioral modification tool for all age groups to bring an improvement in sleep quality. Although sleep quality declines with age, only a very small fraction of the adults in the long follow-up consistently slept poorly while the majority of people sleep well or fairly well (Hublin et al., 2017).

There are several factors, including physiological changes, underlying physical conditions, and psychosocial factors that may contribute to a decrease in sleep quality with age (Kim et al., 2021). Among 176 responses received for this study, 63 of it describes other reasons that contribute to their trouble sleeping. Some of the reasons include stress or mental breakdown, unmanageable workload, fatigue, presence of headache or migraine during the night besides environmental factors such as hot room temperature and disturbing surrounding noise. In addition, overthinking, screen time or social media use before bed, caffeine intake, hunger and food intake before going to sleep were also contributing to their sleep problem.

The findings in this study discovered that both frequency and duration of exercises are not associated with sleep quality. This is supported by a cross-sectional study done by Kakinami et al. (2017) that showed that intensity and duration of physical activity were not associated with sleep quality or quantity. Meanwhile fitness levels and athleticism should be considered as one of the factors that influence the sleep quality of individuals who do nighttime exercise. This is because when comparatively fit populations were studied, longer exercise durations were needed in order to stimulate a sleep response (Sherill et al., 1998). Apart from that, athletic individuals tend to have longer duration of sleep and elevated slow wave sleep or deep sleep thus their sleep quality is most likely not be affected regardless of type of exercise intensity performed (Driver & Taylor, 2000).

However, Youngstedt et al. (1997) found that the duration of exercise was a more consistent moderator variable than other factors considered including fitness and time of day. This is due to the most reliable effects which includes increased total sleep time and REM latency, and decreased REM sleep were only observed for exercise lasting more than 1 hour possibly because these were more clearly described in experimental protocols when compared to other conditions such as fitness and time of day. Above all, regular exercise is said to be associated with lesser incidence of disturbed sleep (Sherill et al., 1998) and generally exercise done before bedtime was deemed to have a negative impact on sleep (Veqar & Hussein, 2012).

Kredlow et al. (2015) stated that it is reasonable to assume that physical intensity may be related to sleep quality. This is supported by a study done by Glavin et al. (2020) that mentioned the type of exercise completed may impact the relationship between exercise timing and sleep. A recent study found that high physical load at work and excessively frequent intensive physical activity are associated with difficulties initiating sleep and may represent a risk factor for insomnia (Dubina et al., 2021).

In contrast, Horne and Moore (1985) stated that exercise does give a thermogenic effect on sleep by promoting the increase of slow wave sleep or deep sleep of an individual. The body temperature increases are proportional to the workload in which exercising at 70% of maximal oxygen utilization (VO_2max) would raise the temperature by approximately 2°C after 15–20 min of continuous work at a constant workload during a 60 min work period and hence, temperature effects could play a greater role in poor sleepers (Driver & Taylor, 2000). Moreover, increased energy expenditure was proven to improve quality of sleep in terms of duration of sleep and slow wave sleep by applying both energy conservation and restorative theories (Adam & Oswald, 1983; Berger & Philips, 1988 in Driver & Taylor, 2000) . Meanwhile, engagement in acute or light exercises was found to be not very effective in improvement in quality of sleep. (Veqar & Hussein, 2012).

Engagement in nighttime exercise, especially strenuous exercise, gives an impact on Muslims ability to wake up early for fajr. From the Islamic perspectives, there are some Muslim sleep traditions in accordance with the practice of the Prophet Muhammad peace be upon him (pbuh) (Sunnah) that Muslims are encouraged to follow which one of them includes having early bedtime and early wake up time (Bahammam, 2011). In one Hadith narrated by Imam al-Bukhari and Muslim discussed on the superiority of the Fajr (early morning) prayer in Sahih Al-Bukhari (SB) and Sahih Muslim (SM) mentioned that Abu Bakr bin Abi Musa stated, "Allah's Messenger (ﷺ) said, 'Whoever prays the two cool prayers (`Asr and Fajr) will go to Paradise.' " [SB 574; SM 635]. Allah (God)'s messenger is referring to Prophet Muhammad (pbuh). This hadith emphasizes the importance of salah, especially the performance of prayer in two cool (not hot) times including a prayer before sunrise (fajr) and a prayer before sunset (asr) and there are rewards for those who observe these two prayers properly of which they will be blessed with paradise (Muhammad Mushfique Ahmad Ayoup, 2020). Prophet Muhammad (pbuh) encouraged his companions not to be involved in any activity after Isha prayer (which also known darkness prayer that usually done around 1.5 to 2 hours after sunset. The Prophet (pbuh) said, "One should not sleep before the night prayer, nor have discussions after it" [SB 574]. Additionally, Muslims are required to wake up for Fajr prayer, which is about one hour before sunrise.

Besides that, it was said that the Prophet (pbuh) usually did not sleep after Fajr prayer and always told his companions that early morning work is blessed by Allah (Bahammam, 2011).

Sleep deficit was known to be associated with lack of concentration and attention. A study done by Mccoy and Strecker (2011) mentioned that evidence of deficits in attention, learning & memory, emotional reactivity, and higher-order cognitive processes including executive function and decision making are presented following sleep disruption. Meanwhile, Niu et al. (2011) mentioned that disturbed circadian rhythm may negatively influence performance and productivity. This may happen due to the lack of sleep that reduces the quality of the information stored in memory, which might occur along with the degenerative process of attention (Ratcliff & Van Dongen, 2018). In short, with poor sleep quality, individuals tend to have deficits in attention. Thus, in terms of prayer they may have difficulties concentrating on what they read during prayer besides having trouble remembering the actual number of steps during prayer.

3.6. Limitations of The Study

There were a few limitations in this study. First of all, Salah Concentration Questionnaire is a subjective measure of concentration in prayer thus the accuracy of concentration in prayer is unable to be obtained. This is because no objective measurement on concentration in prayer was available. Next, inadequate sample size may affect reliable findings in this study as some respondents were excluded from the study. Furthermore, the study was conducted with respondents in uncontrolled environmental conditions hence it is difficult to bring out results in accordance with the previous study in relating effects of night exercise and sleep quality. Other than that, this study was conducted only in Johor thus the results may not be applicable to all populations of Muslims young adults who perform nighttime exercise.

3.7. Future Recommendations

Future research should focus on awareness of sleep hygiene among Muslims as poor sleep quality was proven to give an impact on concentration in prayer (fajr). This is due to the presence of other reasons that contribute to their trouble sleeping despite doing nighttime exercise. Hence, able to contribute as part of sleep promotion strategies. Longitudinal research relating to nighttime exercise, sleep quality and its relation to religious practice as in concentration in prayer (fajr) using control groups is suggested to gain more reliable findings. Further research on how religious the respondents are, was suggested as this research has not considered those as one the variables that may affect both abilities to wake up early for fajr and concentration in salah (fajr) following nighttime exercise. In addition, future study using objective measurement was recommended if there are suitable tools or methods that help measure attention and concentration in salah accurately. Above all, make sure to use larger sample sizes to obtain precise results.

4. CONCLUSION

Overall, there was no significant association between sleep quality and different age intervals. Besides that, duration, average frequency of night exercise also does not affect sleep quality which is in contrast with most of the previous study. As the type of intensity of night exercise that does not have significant association with sleep quality, the type of intensity of nighttime exercise that gives more impact on sleep quality was unable to be determined. Respondents who engage in nighttime strenuous exercise tend to have difficulty waking up early when compared to those who did moderate and light exercise. While the ability to wake up is often associated with sleep deprivation, this study shows contrary results where sleep quality does not affect the ability to wake up early for fajr as most respondents who are unable to wake up early for fajr have good quality of sleep. Other than that, we can conclude that nighttime exercise does not give an impact to concentration in prayer (fajr) although there is significant association between salah concentration and sleep quality. This is due to frequency, duration and type of intensity of night exercise does not impact sleep quality of respondents who engage in nighttime exercise. To sum up, perform strenuous night exercise is not recommended for Muslim as it can affect their ability to wake up early for fajr despite of having good sleep quality.

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