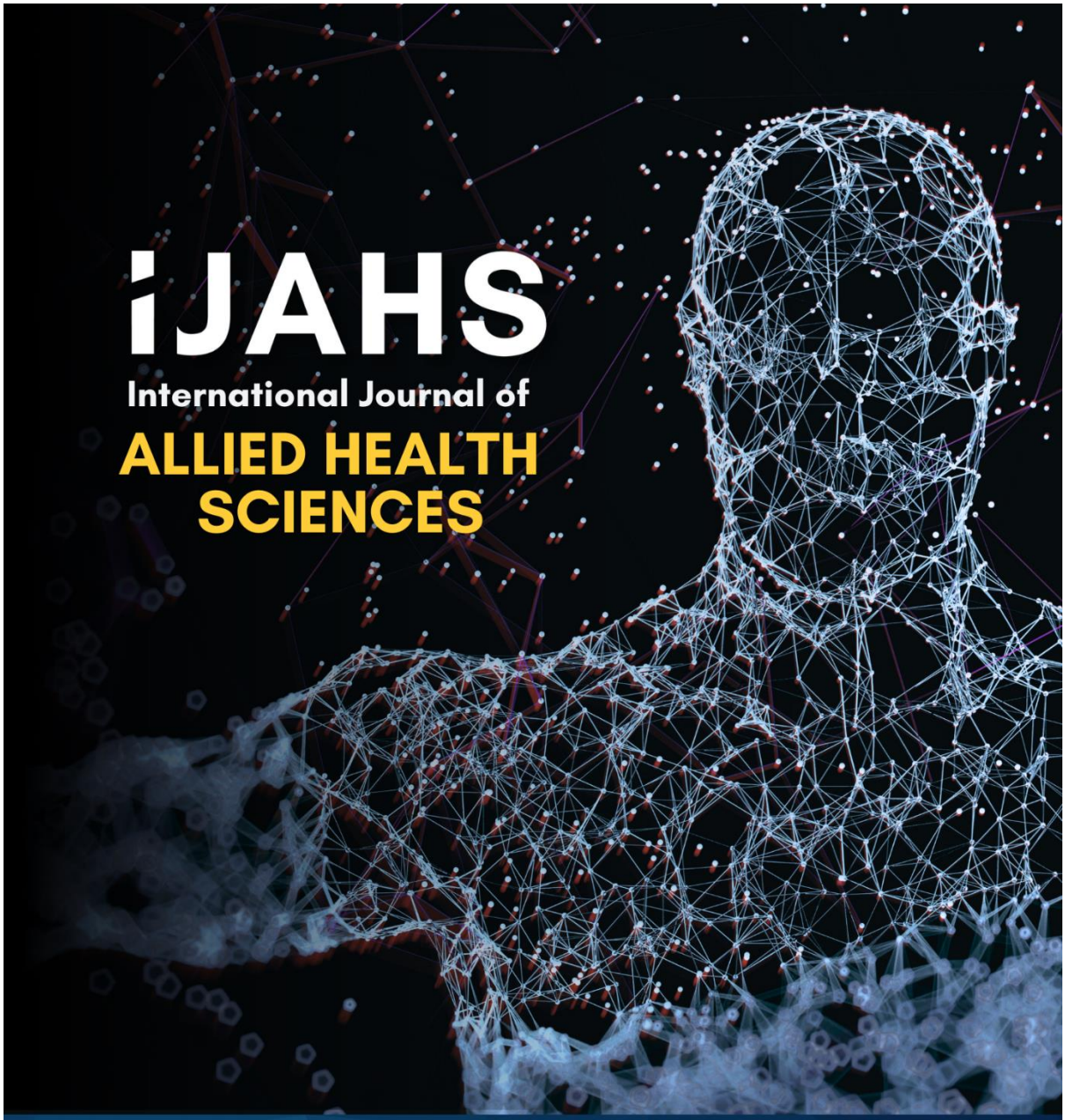

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EDITORIAL

From Revelation to Rehabilitation: The Quran's Relevance in Clinical Linguistics

Language shapes our lives in ways we often take for granted. It is how we express love, share knowledge, and build communities. For Muslims, the Quran is not just a holy book but a living miracle of language- a text that continues to inspire awe for its beauty, depth, and power. In the world of clinical linguistics, language is examined through a scientific lens, focusing on how people acquire, lose, or struggle with speech and communication. But what happens when these two worlds meet? How might the Quran's approach to language and communication offer insights for those who work to heal and rehabilitate speech disorders today?

Anyone who has listened to a skilled recitation of the Quran can attest to its extraordinary linguistic qualities. Its verses flow with rhythm, balance, and a musicality that is both soothing and powerful. The Quran itself draws attention to the miracle of speech:

وَلِسَانًا وَشَفَتَيْنِ ٩

"*And a tongue and two lips*" (Quran 90:9, Khattab, 2016), a simple yet profound reminder of the gift of communication. The text's word choices, patterns, and even its pauses are deliberate, designed to capture attention and stir reflection.

In clinical linguistics, experts spend years studying the mechanics of speech, on how sounds are formed, how words are chosen, and what happens when these processes break down. The Quran's linguistic artistry, with its careful attention to sound and meaning, mirrors the kind of detailed analysis that clinicians use when diagnosing and treating language disorders. Both traditions, in their own ways, recognise that language is as much about art as it is about science.

The Quran does not just celebrate language; it also teaches how to use it well. Time and again, believers are encouraged to speak kindly, honestly, and thoughtfully: "*And speak to them an effective word*" (Quran 4:63, Khattab, 2016), "...*speak to them a word of easy kindness*" (Quran 17:28, Khattab, 2016), and "*And speak to him with gentle speech...*" (Quran 20:44, Khattab, 2016) are just a few examples. The message is clear: words matter, and how we use them matters even more.

This ethical approach to communication is deeply relevant to clinical linguistics. Speech therapists and clinicians know that the way they speak to clients, especially those struggling with language, can make all the difference. A gentle tone, patience, and encouragement can help build confidence and trust, making therapy more effective. The Quran's guidance serves as a timeless reminder that empathy and respect should be at the heart of every interaction.

The Quran is also honest about the challenges of communication. The story of Prophet Musa (عليه السلام) is particularly moving. When Moses is called to deliver God's message, he prays:

وَٱحۡلُلۡ عُقۡدَةٗ مِّن لِّسَانِي ٢٧

"*And remove the impediment from my tongue*" (Quran 20:27, Khattab, 2016), acknowledging his own difficulty with speech. He asks for his brother Harun's (عليه السلام) help (Quran 28:34; 26:13, Khattab, 2016), showing that even the greatest among us may need support.

This narrative is powerful for anyone who has struggled with a speech disorder or worked with someone who has. It reminds us of that the difficulties with language are not a source of shame. Instead, they are part of the human experience, deserving of compassion and understanding. For clinicians, this story reinforces the importance of creating supportive environments where individuals feel safe to express themselves, no matter their challenges.

The Quran describes itself as a source of healing:

وَنُنَزِّلُ مِنَ ٱلْقُرْءَانِ مَا هُوَ شِفَآءٌ وَرَحْمَةٌ لِّلْمُؤْمِنِينَ ۙ وَلَا يَزِيدُ ٱلظَّٰلِمِينَ إِلَّا خَسَارًا ٨٢

"*And We send down of the Quran that which is a healing and a mercy to the believers*" (Quran 17:82, Khattab, 2016). For many, the act of reciting or listening to the Quran brings comfort and peace. But there's more to it than just spiritual solace. The rhythmic patterns, repetition, and melodic recitation can actually support language development and rehabilitation.

In speech therapy, rhythm and repetition are often used to help clients regain fluency or overcome stuttering. The communal aspect of Quranic recitation, in mosques, homes, and schools, offers a supportive setting where individuals can practice pronunciation, intonation, and memory. For those who find confidence in faith, combining spiritual practice with language exercises can be especially powerful.

So, what lessons can clinical linguistics draw from the Quran? First, the ethical use of language, speaking with kindness and clarity, should be central to clinical practice. Second, the Quran's use of rhythm, repetition, and meaningful content offers practical tools for therapy, especially in communities where the Quran is part of daily life. Finally, understanding the cultural and spiritual significance of the Quran can help clinicians build stronger relationships with clients, making therapy more effective and respectful.

From the revelation of the Quran to the rehabilitation of speech and language disorders, the journey of language is one of connection, healing, and hope. By drawing on the Quran's insights- its celebration of language, its compassion for those who struggle, and its ethical guidance we can enrich the science of clinical linguistics and, ultimately, help more people find their voice.

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ORIGINAL ARTICLE

Knowledge, Attitude and Practice of Healthcare Personnel from Sultan Ahmad Shah Medical Centre IIUM on Microorganism Transmission via Mobile Phones

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ABSTRACT

Background: Mobile phones, widely used across all ages and occupations, are high-touch surfaces with the potential to harbour pathogenic microorganisms. Their frequent use in hospital settings enhances medical communication but raises concerns about their role as reservoirs for microbial transmission. This study assessed the knowledge, attitude, and practice (KAP) of healthcare personnel at Sultan Ahmad Shah Medical Centre (SASMEC), IIUM, regarding microorganism transmission via mobile phones. **Methods:** A cross-sectional study involving 271 healthcare personnel was conducted using standardized questionnaires. KAP scores were evaluated through true/false questions, Likert scale statements, and practice assessments. Descriptive and inferential analyses were performed to identify factors influencing KAP. **Results:** Moderate knowledge (59%), good attitude (76.3%), and moderate practices (60.7%) were observed among respondents, with factors such as age and gender influencing scores. Recommendations include implementing UV-C disinfection devices and disinfectant wipes at phone hygiene stations. **Conclusion:** Enhancing healthcare personnel's awareness of microorganism transmission via mobile phones is critical to improving hand and mobile hygiene practices, reducing infection risks, and strengthening hospital infection control measures.

INTRODUCTION

The COVID-19 pandemic heightened global concerns about virus transmission, prompting preventive measures from authorities like the WHO and CDC. A key recommendation is disinfecting high-touch surfaces, including mobile phones, which are widely recognized as potential carriers of infectious diseases. Mobile phones are essential devices used across all demographics and serve as vital communication tools in hospitals, facilitating interactions between healthcare workers and patients. Zakai et al. (2016) highlighted improved medical outcomes in asthma and diabetes patients due to mobile phone use.

However, mobile phones in hospital settings raise concerns as reservoirs for pathogenic bacteria. Wagoner et al. (2019) noted that mobile devices, often kept warm and close to the body, provide ideal conditions for bacterial growth. AlOmani et al. (2020) found mobile phones to harbour more microorganisms than toilet seats, shoelaces, or doorknobs, prompting increased research into bacterial contamination on healthcare workers' phones.

Brady et al. (2012) first linked mobile phones to hospital-acquired infections, identifying contaminants such as Coagulase-negative *Staphylococcus* and *Bacillus* spp. Similarly, Missri et al. (2019) found pathogenic bacteria on nearly 40% of mobile phones in a French ICU, emphasizing their role in microorganism transmission among healthcare staff.

This study offers critical insights into healthcare workers' knowledge, attitudes, and practices, identifying behavioural gaps to guide improvements in hygiene practices and reduce transmission risks in healthcare settings.

MATERIALS AND METHODS

Study Design and Setting

The study was approved by the Kulliyyah Postgraduate and Research Committee (KPGRC) and the IIUM Research Ethics Committee (IREC), ensuring respondent confidentiality. A cross-sectional survey was conducted from March to May 2021 to assess the knowledge, attitude, and practices (KAP) of healthcare personnel regarding microorganism transmission via mobile phones at SASMEC, IIUM.

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Study Population and Sampling

The study included healthcare personnel such as doctors, nurses, lab technologists, pharmacists, and administrative staff who used mobile phones during work hours and understood English or Malay. Practical students, interns, and non-phone users were excluded. Using the Raosoft Sample Size Calculator (5% margin of error, 95% confidence interval), a sample size of 301 was determined, accounting for a 10% dropout rate. Random sampling was employed, and an online questionnaire was distributed via WhatsApp.

Questionnaire Development

A structured questionnaire was designed and validated based on Kaliyaperumal's (2004) KAP guidelines, covering demographics, knowledge, attitude (Likert scale), practices, and open-ended questions on mobile hygiene practices.

Data Collection

Data were collected through self-administered questionnaires. Participation was voluntary, with informed consent obtained, and participants could withdraw at any time without losing benefits. Questionnaires were distributed online via Google Forms (shared through WhatsApp and email) and as hard copies to SASMEC healthcare personnel. Responses were analyzed using SPSS, with data assessed for normality prior to statistical tests. The scoring system for Knowledge, Attitude, and Practice (KAP) regarding pathogen transmission via mobile phones is detailed in Tables 1 and 2.

Table 1: Scoring system for different categories of KAP

Percentage of total score (%)	Total score of knowledge	Total score of attitude	Total score of practice	Category
≥70	19 - 26	32 – 45	19 – 27	Good
51 – 69	14 - 18	23 – 31	14 – 18	Moderate
≤50	0 – 13	10 – 23	10 – 14	Poor

Note. This scoring system was adapted from the study of Basir et al. (2020) with slight modification.

RESULTS

Sociodemographic Characteristics of Respondents

A total of 173 healthcare personnel from SASMEC@IIUM participated in the survey. Most respondents were female (69.9%) and aged between 26-33 years (53.8%). Nursing staff constituted the largest group (28.3%), while dieticians represented the smallest group (0.6%). Most respondents had 2-5 years of service (43.4%), and over half attended to patients daily (57.2%). All participants owned at least one mobile phone and brought it to work every day.

Table 2: Scoring system for each item in knowledge, attitude and practice

Response	Score
Knowledge	
Correct Statement	
True	2
Not sure	1
False	0
False statement	
True	0
Not sure	1
False	2
Attitude	
Positive statement	
Strongly agree	5
Agree	4
Neither agree nor disagree	3
Disagree	2
Strongly disagree	1
Negative statement	
Strongly agree	1
Agree	2
Neither agree nor disagree	3
Disagree	4
Strongly disagree	5
Practice	
Positive statement	
Often	3
Seldom	2
Never	1
Negative statement	
Often	1
Seldom	2
Never	3

Knowledge, Attitude, and Practice (KAP) Regarding Microorganism Transmission via Mobile Phones

Table 3 displays frequency distribution of scores (good, moderate and poor) for knowledge, attitude and practice towards microorganism transmission via mobile phones. The table shows that more than half of the staff falls in the category of moderate score for knowledge and practice with 59% and 60.7% respectively. However, the majority of the staff achieved good attitude scores with 76.3% and only 16.2% achieved moderate scores for attitude.

Most respondents (76.9%) recognized mobile phones as potential transmitters of microorganisms, but many underestimated the risks compared to other surfaces like toilet seats. While pathogen definitions and common fomites (e.g., doorknobs, mobile phones) were well understood, 17.3% were unsure about faucets as fomites (Table 4).

Attitudes towards hygiene were largely positive, with 76.3% of respondents scoring well. Most agreed microorganisms were present on mobile phones (66.5%) and supported regular cleaning (50.9%). However, 33.5% viewed indirect transmission as less severe than direct, and 36.4% were unsure about mobile phones causing healthcare-associated infections, highlighting awareness gaps (Table 5).

Mobile phone hygiene practices were moderate, with 60.7% scoring in the moderate range. Although 82.7% frequently used phones at work, only 31.8% cleaned them daily. Less than half practiced hand hygiene before (39.3%) and after (35.8%) phone use. Notably, 48.6% changed gloves before attending to patients after using phones, and 46.2% never shared their phones with others. (Table 6).

Table 3: Categories of knowledge, attitude, and practice scores concerning microorganism transmission via mobile phone (n = 173)

Category	Frequency	Percentage (%)
Knowledge		
Good (≥70%)	61	35.3
Moderate (51% – 69%)	102	59.0
Poor (≤50%)	10	5.8
Attitude		
Good (≥70%)	132	76.3
Moderate (51% – 69%)	28	16.2
Poor (≤50%)	13	7.5
Practice		
Good (≥70%)	52	30.1
Moderate (51% – 69%)	105	60.7
Poor (≤50%)	16	9.2

Table 4: Responses on knowledge concerning microorganism transmission (n = 173)

No.	Statements	True N (%)	False N (%)	Not Sure N (%)
1.	Pathogen can be defined as an organism that can cause disease to its host	**143 (82.7)**	1 (0.6)	29 (16.8)
2.	Microorganism may be transmitted via mobile phone.	**133 (76.9)**	14 (8.1)	26 (15)
3.	Mobile phones have lower risk to harbour microorganism as compared to toilet surfaces (e.g. door handles, toilet seat, and toilet flush handle).	84 (48.6)	51 (**29.5**)	38 (22)
4.	Cross-contamination (transfer of bacteria or other microorganisms from one substance to another) highly occurs on surfaces of healthcare related building (e.g. hospital) than public settings (e.g. supermarket).	116 (67.1)	**26 (15)**	31 (17.9)
5.	Most species of bacteria can only survive for two weeks on dry inanimate surfaces.	60 (34.7)	**18 (10.4)**	95 (54.9)
6.	Most viruses from the respiratory tract, such as *corona*virus, *influenza, SARS,* or *rhino*virus, can survive on dry inanimate surfaces for one to seven days.	**99 (57.2)**	21 (12.1)	53 (30.6)
7.	Major phones manufacturer (e.g. Samsung, Apple and Google) has published proper disinfections guide for mobile phone	**40 (23.1)**	87 (50.3)	46 (26.6)
8.	Hand sanitizer has the same effectiveness on reducing the number of microorganisms on hand as compared to soap and water.	111 (64.2)	**36 (20.8)**	26 (15)
9.	Below listed item(s) can be potentially categorized as fomite (Fomite: inanimate object that serves as a mechanism of transfer for infectious agents between hosts.)			
	(a) Doorknob	**160 (92.5)**	0	13 (7.5)
	(b) Mobile Phone	**155 (89.6)**	2 (1.2)	16 (9.2)
	(c) Stethoscope	**134 (77.5)**	7 (4.0)	32 (18.5)
	(d) Lift Button	**163 (94.2)**	0	10 (5.8)
	(e) Faucet/water tap	**138 (79.8)**	30 (17.3)	5 (2.9)

Note. Correct answers are in bold.

Table 5: Responses on attitude statements concerning microorganism transmission (n = 173)

No	Statement	Strongly Disagree n (%)	Disagree n (%)	Neither Agree nor Disagree n (%)	Agree n (%)	Strongly Agree n (%)
1.	I am aware that microorganisms are present on mobile phones.	9 (5.2)	4 (2.3)	13 (7.5)	32(18.5)	**115 (66.5)**
2.	I believe that microorganisms on mobile phones surface cannot be transmitted to human.	**67 (38.7)**	47 (27.2)	35 (20.2)	13 (7.5)	11 (6.4)
3.	I believe that indirect transmission of pathogens by touching mobile phones is not as severe as direct transmission such as person-to-person contact.	24 (13.9)	28 (16.2)	38 (22)	58 (33.5)	**25 (14.5)**
4.	I believe that touching a mobile phone using gloves is an improper action.	20 (11.6)	22 (12.7)	31 (17.9)	42 (24.3)	**58 (33.5)**
5.	I should only clean my hands after touching public surfaces (e.g. shopping cart handle).	**67 (38.7)**	25 (14.5)	21 (12.1)	33 (19.1)	27 (15.6)
6.	I believe that I would clean my phone more often if there was a readily accessible disinfection tool at the workplace	8 (4.6)	8 (4.6)	18 (10.4)	39 (22.5)	**100 (57.8)**
7.	I believe that frequent hand cleaning before and/or after touching mobile phones will reduce the presence of microorganisms on mobile phones.	9 (5.2)	8 (4.6)	16 (9.2)	44 (25.4)	**96 (55.5)**
8.	I believe that mobile phones are a source of healthcare associated infection.	10 (5.8)	15 (8.7)	63 (36.4)	40 (23.1)	**45 (26)**
9.	I believe that mobile phone should be cleaned on a regular basis.	10 (5.8)	3 (1.7)	28 (16.2)	44 (25.4)	**88 (50.9)**

Note. Correct answers are in bold.

Table 6: Responses on practice concerning microorganism transmission (n = 173)

No	Statement	Never N (%)	Seldom N (%)	Often N(%)
1.	I use my mobile phone at work	**1 (0.6)**	29 (16.8)	143 (82.7)
2.	I use my phone at least once every hour	**5 (2.9)**	45 (26)	123 (71.1)
3.	I clean my mobile phone with disinfection wipes/alcohol swabs every day.	26 (15)	92 (53.2)	**55 (31.8)**
4.	If I'm using my mobile phone with gloves on, I change the gloves before attending to the patient.	51 (29.5)	38 (22)	**84 (48.6)**
5.	I bring my mobile phone to the restroom/toilet.	**38 (22)**	71 (41)	64 (37)
6.	I use my mobile phone while eating during break time.	**18 (10.4)**	55 (31.8)	100 (57.8)
7.	I share my mobile phone with workmates or family members	**80 (46.2)**	57 (32.9)	36 (20.8)
8.	I clean my hands using alcohol wipes/hand sanitizers/soap and water before touching the mobile phone	17 (9.8)	80 (50.9)	**68 (39.3)**
9.	I clean my hands using alcohol wipes/hand sanitizers/soap and water after touching the mobile phone	29 (16.8)	82 (47.4)	**62 (35.8)**

Note. Expected answers are in bold.

Association of Sociodemographic Factors with KAP on Microorganism Transmission

As can be seen in Table 7, one-way ANOVA was used to analyze knowledge differences on microorganism transmission based on sociodemographic factors. Age group was found to significantly affect knowledge (p=0.018), with the group above 33 years old (M=16.50) scoring significantly lower than the group under 26 years old (M=17.89) and 26-33 years old (M=18.06) group.

Table 7: Comparison of total mean knowledge scores on microorganism transmission between different age group using one-way ANOVA test (n = 173)

Age Group	*n*	Knowledge score (%)		*F*-statistic *(df)*	*p*-value
		Mean	*SD*		
Under 26 years old	56	17.89	2.229	4.128	0.018*
26-33 years old	93	18.06	2.536	(2, 170)	
Above 33 years old	24	16.50	2.226		

*p <0 .05 shows a significant difference.

Table 8 shows a significant difference in attitude scores based on age group ($\chi^2 = 8.842$, p=0.012). The 26-33 years old group had the highest attitude score (mean rank = 92.42), with significant differences between under 26

years old and above 33 years old groups (p=0.008) and 26-33 years old vs above 33 years old (p=0.004).

Table 8: Comparison of attitude scores on microorganism transmission between age groups using Kruskal-Wallis test (n = 173)

Age Group	*n*	Mean rank	df	*χ 2*	*p*-value
Under 26 years old	56	89.89	2	8.842	0.012*
26-33 years old	93	92.42			
Above 33 years old	24	59.23			

**p<0.05* shows a significant difference.

Table 9: Comparison of practice scores concerning microorganism transmission between different genders and involvement in attending patient using Mann-Whitney U test (n = 173)

Gender	*n*	Mean rank	U	*z*	*p*-value
Female	121	93.70	2335.5	-2.699	0.007*
Male	53	71.41			

**p* < 0.05 shows a significant difference.

There were significant differences in practice scores between genders (p=0.007), with females having higher practice scores (mean rank = 93.70) (Table 9). There were also significant differences in practice scores between the age groups (χ^2 = 10.378, p=0.006), with the under 26 years old group showing the highest practice score (mean rank = 100.97). Post-hoc analysis revealed significant differences between under 26 years old and above 33 years old groups (p=0.005).

Suggestions for Reducing Microorganism Transmission via Mobile Phones in Hospitals

The respondents provided various suggestions to minimize microorganism transmission through mobile phones in hospitals. The most common recommendation (42 respondents, 50.6%) was to place UV phone sanitizers at designated hygiene stations. Other proposals included disinfection wipes (23 respondents, 27.7%), alcohol swabs (8 respondents, 9.6%), and plastic phone covers (10 respondents, 12.0%).

Additionally, respondents emphasised the importance of regular phone disinfection (37 respondents, 37.4%) and proper hand hygiene (32 respondents, 32.3%) before and after phone use. Other suggestions included reducing phone usage during work hours (19 respondents, 19.2%), increasing awareness through campaigns and training (9 respondents, 9.1%), and avoiding sharing personal phones (2 respondents, 2.0%).

DISCUSSION

KAP Concerning Microorganism Transmission via Mobile Phones

The webpage "How are COVID-19 key indicators trending in Pahang?" (2025) from the KKMNOW platform by the Ministry of Health Malaysia highlights a significant surge in COVID-19 cases in Pahang between March and May 2021. Cases increased sharply from 912 on 1 April 2021 to 4,399 on 1 May 2021, emphasizing the timeliness and relevance of conducting the study during this critical period.

During the study period, students were instructed to adhere to the Movement Control Order (MCO) implemented by the campus. While clinical postings at SASMEC were permitted, they were conducted under strict Standard Operating Procedures (SOPs) established by SASMEC. Students were strongly encouraged to minimise physical contact and avoid crowded areas within the hospital. To distribute the survey, hardcopies were provided to healthcare personnel who were accessible to the author. Additionally, online platforms were utilised to enhance data collection and ensure a more representative dataset.

Most respondents (59%) demonstrated moderate knowledge about microorganism transmission via mobile phones, influenced by their educational backgrounds (e.g., administrative staff, engineers, radiologists, doctors, and science officers) and increased awareness during the COVID-19 pandemic. As shown in Table 4, 67.1% of respondents agreed with Statement 4, believing that cross-contamination occurs more frequently in healthcare settings, reinforcing the perception of hospitals as high-risk environments during the outbreak. Meanwhile, 15% disagreed, and 17.9% were unsure, highlighting gaps in understanding microbial risks. Similarly, for Statement 5, more than half (54.9%) were uncertain about bacterial survival on dry surfaces, possibly due to limited microbiological knowledge among non-science professionals.

Misconceptions were also evident regarding microbial contamination levels on mobile phones compared to toilet surfaces and the survival of bacteria on dry surfaces. Although many respondents recognised the importance of hand washing, fewer understood the effectiveness of hand sanitizers, and awareness of mobile phone disinfection guidelines, such as those from manufacturers like Apple, was limited. These findings emphasise the need for targeted education to correct misconceptions and improve awareness of microbial transmission, especially during public health crises.

The majority (76.3%) exhibited good attitudes toward preventing microorganism transmission. Most acknowledged the potential contamination of mobile phones and agreed on the importance of regular disinfection. Studies, including those by Ulger et al. (2015) and Jalalmanesh et al. (2017), emphasise mobile phones as fomites for nosocomial infections. Respondents also agreed on the benefits of combining hand hygiene with surface cleaning to reduce contamination.

While 60.7% demonstrated moderate practices, nearly one-third showed good practices. Hence, inconsistencies in proper disinfection remain evident. Regular mobile phone cleaning and adherence to hygiene practices, such as hand washing, were the most reported actions, aligning with Malhotra et al. (2020), who emphasised the importance of workplace disinfection tools.

The vital role of mobile phones for healthcare personnel is evident, with 82.7% reporting frequent use at work. Despite high knowledge levels, a gap between awareness, attitude, and practice persists. For instance, while 67.1% of respondents recognized the risk of cross-contamination in healthcare settings (Statement 4), only 31.8% cleaned their phones daily, and 48.6% changed gloves after phone use before patient care. Furthermore, 37% admitted to bringing phones into restrooms, a known high-contamination area.

For Statement 5, uncertainty regarding bacterial survival on dry surfaces (54.9% Not Sure) likely contributes to these inconsistent practices. While respondents understand the risks of microbial transmission, translating this knowledge into reliable infection control practices remains a challenge. The anonymous nature of the survey encouraged honest responses, providing valuable insights into real-world behaviours. These findings underscore the need for targeted interventions to bridge the gap between knowledge and practice, ensuring consistent and effective infection control among healthcare professionals.

Factors Associated with KAP Concerning Microorganism Transmission via Mobile Phones

Age significantly influenced knowledge scores, with the 26–33 age group scoring highest and those above 33 scoring lowest. This contrasts with Desta et al. (2018), who found higher knowledge among older healthcare personnel. Younger personnel's higher scores may be linked to their active social media use, as highlighted by Hj Ahmad, Ismail, & Nasir (n.d.), where 18–34-year-olds are the largest social media users in Malaysia. Social media's role in sharing COVID-19 awareness likely enhanced their knowledge. Other factors, such as gender, staff category, and years of service, showed no significant impact on knowledge scores.

Attitude scores mirrored knowledge trends, with the 26–33 age group scoring highest. Post hoc tests revealed a significant difference between those above 33 and younger groups. These findings suggest that younger healthcare personnel's exposure to social media has positively influenced their attitudes, aligning with Ul Haq et al.'s (2012) definition of attitude as a predisposition shaped by knowledge.

Gender significantly influenced practice scores, with females scoring higher, which is consistent with findings from Jalalmanesh et al. (2017) and Mon et al. (2020), both of whom observed better phone hygiene practices among females. This study supports these findings, demonstrating a significant difference in practice scores between male and female respondents. Jalalmanesh et al. (2017) found that female medical students cleaned their phones more frequently than their male counterparts, resulting in lower levels of microbial contamination on their devices. Similarly, Mon et al. (2020) reported that females exhibited higher levels of mobile phone hygiene compared to males. These studies collectively highlight the gender-related differences in hygiene practices, particularly in healthcare settings, and underscore the importance of targeted interventions to improve phone hygiene among all healthcare personnel. Age also influenced practice scores, with significant differences between those above 33 and under 26, aligning with trends in knowledge and attitude.

Suggestions for Phone Hygiene Stations in Hospitals and Reducing Microorganism Transmission via Mobile Phones

Participants suggested various measures to improve phone hygiene in hospitals. The most recommended solution was the use of UV-C light technology, which has proven effectiveness in reducing bacterial contamination. Malhotra et al. (2020) demonstrated that a UV-C disinfection device reduced bacterial colonies by 99.9% after two cycles. This method is already widely used in hospitals to disinfect patient rooms, pharmacy clean-rooms, and operating rooms, proving effective against pathogens such as MRSA, *Clostridioides difficile*, and norovirus.

Another suggestion was the provision of disinfectant wipes or alcohol swabs at hygiene stations, as these are cost-effective, easy to implement, and effective. Studies, such

as Brady et al. (2012), showed a 79% reduction in bacteria after using 70% isopropyl alcohol wipes. Similarly, Leong et al. (2020) found that hygiene stations equipped with disinfectant wipes and educational materials increased daily phone cleaning among users. Plastic covers for phones were also proposed as a practical solution. Wu et al. (2020) found that temporary plastic wraps combined with alcohol wipes effectively prevent microbial colonization, with no additional contamination compared to uncovered phones.

To minimise microorganism transmission via mobile phones, respondents emphasised the importance of promoting frequent hand hygiene. Proper hand washing before and after phone use aligns with CDC (2020) guidelines, which highlight hand hygiene as one of the most effective measures against pathogen transmission, especially during the COVID-19 pandemic. Regular phone disinfection was another widely supported suggestion, with CDC guidelines recommending daily cleaning of high-touch surfaces like phones to reduce the risk of contamination and infection from virus-laden surfaces.

While some respondents suggested reducing phone use in healthcare settings, this approach is impractical due to the integral role of mobile phones in patient care (Ulger et al., 2015). Instead, implementing usage restrictions in high-risk areas, such as ICUs and operating theatres, was seen as a more feasible alternative. Increasing awareness among healthcare personnel was also proposed, with strategies such as regular announcements, posters, and signage emphasising phone hygiene and its role in pathogen transmission. Lastly, respondents highlighted the importance of avoiding phone sharing, as it significantly reduces the risk of cross-contamination.

CONCLUSION

This study found that healthcare personnel had moderate knowledge (60%) and practice (61%) but a good attitude (77%) regarding microorganism transmission via mobile phones. Age influenced KAP levels, with older personnel performing better. Implementing UV-C disinfection devices and providing disinfectant wipes at phone hygiene stations were the top recommendations. These findings can raise awareness, encourage regular hygiene practices, and guide SASMEC management in adopting preventive measures to reduce transmission risks.

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ORIGINAL ARTICLE

Pelvic Floor Muscle Exercise for Reducing Urinary Incontinence: Knowledge and Attitude Among the Postnatal Mothers

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ABSTRACT

Background: Urinary incontinence is a prevalent issue for young women during pregnancy and postpartum, affecting their quality of life and leading to mental health issues like depression and poor self-esteem. Providing clear information about postnatal registration and pelvic floor muscle exercises (PFME) can help identify symptoms and take appropriate action. This study assessed the level of knowledge and attitude on PFME for reducing urinary incontinence among the postnatal multiparous pregnant women in selected hospitals in Dhaka city, Bangladesh. **Methods:** Cross-sectional research with 121 participants, using a non-probability sampling approach, was conducted on postnatal mothers at the Maternal and Child Health Training Institute, the Institute of Child & Mother Health, and Dhaka Medical College and Hospital in Bangladesh, using SPSS version 20 for analysis. **Results:** Most participants (n=84, 69%) are aware of the benefits of exercising the pelvic floor muscle. The findings revealed that 59 (48.8%) of the 121 participants had experienced urinary incontinence, and 37 (30.6%) had followed the Kegel exercise treatment. One hundred and three (85.1%) of postnatal mothers expressed their views on the value of pelvic floor muscle training for expectant mothers. Overall, 78 (64.76%) of participants had this degree of understanding, and 87 (71.96%) had this attitude. **Conclusion:** This study provides information on PFME, highlighting its benefits for postpartum management and preventing pregnancy complications. It suggests that knowledgeable postpartum mothers can adopt a positive attitude towards pelvic floor workouts, strengthening and relaxing PFMs.

INTRODUCTION

Pelvic floor disorders are increasingly recognized as significant health issues affecting women globally, particularly in developing nations. These conditions impact millions of individuals, often without their knowledge, due to limited access to healthcare, as well as a lack of awareness and autonomy in decision-making regarding the management of pelvic floor disorders. The prevalence of these disorders varies widely across different countries, ranging from 11.9% to 67.5%. In high-income nations, such as the United States, approximately 25% of women report experiencing at least one pelvic floor disorder during their lifetime, with urinary incontinence being the most prevalent at 17.1%, followed by fecal incontinence at 9.4% and pelvic organ prolapse at 2.9%. Conversely, the incidence of pelvic floor disorders is notably higher in developing countries; for example, in Bangladesh, the prevalence is reported at 35.3%, with urinary incontinence constituting 23.7%, fecal incontinence at 5.3%, and pelvic organ prolapse at 16.2% (Demissie et al., 2024).

Lifestyle changes such as adopting a healthier diet, exercising regularly, and maintaining an optimal weight are effective in preventing and treating pelvic floor dysfunction. Among physical interventions, PFME has proven to strengthen the pelvic floor muscles (Huang, 2023).

The pelvic floor consists of a group of muscles interconnected by ligaments, forming a dome-shaped diaphragm that covers the bony pelvic outlet. This intricate arrangement of muscles extends from the pubis at the front to the sacrum and coccyx at the back, as well as laterally to the ischial tuberosities. The pelvic floor muscles serve three primary functions: They provide support for

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the pelvic organs, including the bladder, urethra, prostate (in males), vagina and uterus (in females), as well as the anus and rectum, while also offering general support to the contents within the abdominal cavity. They play a crucial role in maintaining urinary and fecal continence. They are involved in sexual functions, specifically in relation to arousal and orgasm (Grimes & Stratton, 2022).

The inadequacy of pelvic floor muscles in females may result in pelvic floor dysfunction, consequently heightening the likelihood of urinary and fecal incontinence. Additionally, since these muscles offer essential physical support to the reproductive organs, their weakness can contribute to prolapse of the reproductive organs, sexual dysfunction, and may affect sexual arousal and the experience of orgasm (Derrar et al., 2022).

For strengthening the PFM, Kegel exercises are the most popular and widely recommended. First described in 1948 by American physician Arnold H. Kegel, these exercises involve contracting and relaxing the PFM repeatedly. It may be developed further or changed to create additional variations. It is frequently advised to carry out the exercise numerous times a day for a few minutes each time. For the desired results, it must be done for a minimum of one to three months. The purpose of pelvic floor muscle exercises for postnatal multiparous mothers is to enhance the tone and strength of their PFM. Strong pelvic floor muscles, particularly after childbirth, aid in preventing urinary stress incontinence by improving the ability to retain urine (Okeke, 2020).

A study by Muhammad et al. (2019) of European nations indicated prevalence rates ranging from 23% to 44%. Notably, the prevalence appears to be elevated during pregnancy, with 45% in the later stages of pregnancy, while Francis noted a prevalence of 6% to 31% in the postpartum period. In Malaysia, the prevalence among women attending outpatient clinics was found to be 40.4%, and 22.1% among women five months after childbirth. Additionally, one study revealed that 76.6% of women visiting a menopause clinic exhibited some level of uterine prolapse. Despite the high rates of pelvic floor muscle dysfunction (PFMD), the practice of PFME remains low among women. Only 17% of antenatal mothers engaged in PFME at least once a week during their pregnancy, and another study indicated a usage rate of 54%.

In addition to fecal and/or urinary incontinence (UI), prolapse of the female reproductive organs is another common symptom of female pelvic floor dysfunction. Depending on the classification, the proportion of women with pelvic floor dysfunction varies from 30% to 50%. A 2007 health study on urine incontinence from the Robert Koch Institute states that numerous common myths and preconceptions concerning pelvic floor dysfunction, particularly with regard to urinary incontinence, impede people from seeking proper therapy and preventative strategies. Many individuals think that since incontinence is a natural aspect of aging, treating it is pointless and unlikely to be successful (Jundt, 2015).

Exercises aimed at strengthening the pelvic floor muscles (PFM) have been demonstrated to alleviate urinary incontinence during pregnancy, the postpartum period, and beyond. Furthermore, these exercises decrease the occurrence of fecal incontinence episodes following childbirth and improve sexual dysfunction during this time, as noted by the National Institute for Health and Care Excellence, (Boyle et al., 2014, and Mørkved et al., 2014). Studies have shown how beneficial PFME are for preventing fecal and urinary incontinence (Park et al., 2013). Kegel exercises are typically performed with an empty bladder. Either sitting or lying down, the individual contracts their pelvic floor muscle, keeps it there, and counts for three to five seconds, and relaxes (Wesnes et al., 2012).

Urinary incontinence represents a significant public health issue for women, affecting their physical, psychological, and social well-being, while also being associated with financial difficulties. It has been established for some time that pregnancy poses a risk for the onset of urinary incontinence, which may become increasingly prevalent as women age or progress through different stages of life. Postpartum urinary incontinence is a notable and often overlooked contributor to morbidity among mothers (Fritel, 2012 and Lukacz, 2011).

PFME education represents a valuable and low-risk approach that can substantially decrease urinary incontinence across diverse populations and should be prioritized as an initial intervention. For PFME to be effective, postnatal mothers must be able to contract the right muscles and follow a certain exercise plan. A postnatal mother's ability to perform an effective pelvic muscle contraction cannot be determined merely by clinical factors such as age, severity, urethral support, or urethral profile. Vaginal examination is essential for identifying active contractions and determining a proper exercise routine. Pelvic floor muscle exercise helps to recover bladder control, prevent prolapse, and support the restoration of normal sexual function for both partners. This study encourages postnatal mothers to actively participate in pelvic floor muscle exercises as often as possible. To mitigate urinary incontinence concerns, healthcare professionals must effectively instruct their

clients on the proper execution of Kegel exercises and emphasize the importance of consistency. Enhancing health education is crucial for improving comprehension of pelvic floor muscle exercises, which not only helps in preventing urinary incontinence but also facilitates the recovery of normal bladder function. This study aims to assess the level of knowledge and attitudes toward PFME and to determine whether this exercise can prevent UI among postnatal mothers.

MATERIALS AND METHODS

A cross-sectional descriptive study was designed with a sample size of 121 postnatal mothers. The sampling method employed was non-probability convenience sampling. Data was collected from three tertiary healthcare institutions: the Maternal & Child Health Training Institute, the Institute of Child & Mother Health, and Dhaka Medical College and Hospital, all located in Dhaka City, Bangladesh. This study aimed to assess the levels of knowledge and attitudes on pelvic floor muscle exercise for reducing urinary incontinence among the postnatal multiparous pregnant mothers.

The study period was from 1st July 2018 to 30th December 2019, with data collected between August and September 2018. Before beginning the data collecting process, the data collector received an orientation from the supervisor about the questionnaires and the criteria for their implementation. Before the interview, a verbal briefing was given to clarify the purpose of the interview. The study population then gave informed written consent, as necessary. A structured questionnaire designed by the researchers in accordance with the study's objectives and variables was used. Data was collected through face-to-face interviews. Each participant had around 30 minutes to complete the questionnaire.

The questionnaire was divided into three sections. Section I focused on demographic information, including age, height, weight, religion, number of children, type of family, place of residence, educational level, and family income. Section II evaluated participants' knowledge of pelvic floor muscle exercises, such as awareness of exercises, prior practice, and contributing factors like postpartum problems, constipation, persistent coughing or sneezing, and being overweight. Section III assessed participants' attitudes toward pelvic floor muscle exercises, including their perceived importance and willingness to perform them. Knowledge and attitude levels were categorized as low (1–33%), medium (34–66%), and high (67–100%) based on predefined values. Data was collected and checked for accuracy on a daily basis. As part of the coding procedure after data collection, each response was assigned a unique serial number. Every day, the data was checked, cleaned, and validated to ensure that there were no errors or inconsistencies. Data entry, management, and analysis were carried out using version 20 of SPSS (Statistical Package for the Social Sciences). The data analysis was carried out through the application of descriptive statistics, which primarily concentrated on assessing frequency and percentage distributions. In addition, inferential statistics were utilized to investigate the relationship between specific sociodemographic characteristics and the level of knowledge and attitude regarding PFME. To determine statistical significance, a p-value was employed, allowing for a rigorous evaluation of the findings.

The study was approved by the Ethical Review Committee of Bangladesh University of Health Sciences (BUHS). Participants selected for the study were provided with a comprehensive overview of the research, and their consent was obtained prior to participation. Written consent was secured from all individuals before their recruitment. They received an explanation of the study in Bengali, a language they comprehend. The study was designed to ensure that no harm of any nature came to the participants. Participants were given the option to withdraw from the study at any time should they wish to do so. Data confidentiality was guaranteed, with all information stored in locked cabinets that are not accessible to unauthorized individuals. Access to the data is restricted to the researcher, and those conducting statistical analyses. The information and results obtained from the study are to be used completely for the purposes of the research.

RESULTS

Socio-demographic Characteristics of the Postnatal Mothers

Table 1 presents data that outlines the demographic, socioeconomic, and familial characteristics of 121 postnatal mothers. This analysis emphasizes their age distribution, religious affiliation, family structure, number of children, educational attainment, residential area, and monthly family income. The key findings from the data are as follows: The largest group of mothers, 34 (28.1%) were aged 40-44 years; mothers aged 35-39 years comprised 32 (26.4%). A significant portion of 26 (21.5%) mothers were over 45 years old. Younger age groups were less represented, with 10 (8.3%) aged 25-29 years and 30-34 years. Nine (7.4%) mothers were aged below 20 years or 20-24 years. A majority of 50 (41.3%) participants were identified as Muslim. The smallest group, 16 (13.2%), were identified as Buddhist. Most mothers had a significant

number of children. Forty (33.1%) had four or more children, 25 (20.7%) had three children and 16 (13.2%) had two children. 58.7% of mothers belonged to nuclear families. 39 (32.2%) lived in joint families. 11 (9.1%) were part of broken or extended families. A large majority, 88 (72.7%) of mothers lived in urban areas. Only 11 (9.1%) resided in semi-urban regions. A large majority, 88 (72.7%) of mothers lived in urban areas. Only 11 (9.1%) resided in semi-urban regions. Sixty-three (52.1%) mothers had a primary-level education, 32 (26.4%) had completed secondary education, 9 (7.4%) reached higher secondary levels and 17 (14.0%) were illiterate. Most families, 46 (38%), earned between 10,001 and 20,000 taka, 44 (36.4%) earned below 10,000 taka, while the other 31 (25.6%) earned between 20,001 and 30,000 taka.

Table 1: Socio-demographic characteristics of participants of the study (n=121)

Variable	Frequency	Percentage (%)
Age (in years)		
Less than 20 & 20-24	9	7.4
25-29	10	8.3
30-34	10	8.3
35-39	32	26.4
40-44	34	28.1
More than 45	26	21.5
Religion		
Islam	50	41.3
Hindu	33	27.3
Christian	22	18.2
Buddhist	16	13.2
Number of children		
Two	16	13.2
Three	25	20.7
Four	40	33.1
More than four	40	33.1
Type of family		
Nuclear family	71	58.7
Joint family	39	32.2
Broken/Extended Family	11	9.1
Residence area		
Rural	22	18.2
Urban	88	72.7
Semi-Urban	11	9.1
Level of last education		
Illiterate	17	14.0
Primary	63	52.0
Secondary School Certificate	32	26.4
Higher Secondary Certificate	9	7.4
Monthly family income		
Below 10,000/=	44	36.4
10,001-20,000/=	46	38.0
20,001-30,000/=	31	25.6

Findings Related to Knowledge and Attitude

The data presented highlights various health concerns, knowledge, and attitude gaps related to pelvic health among postnatal mothers. Figure 1 illustrated that a majority, 84 (69%), of participants are aware of pelvic floor muscle exercises but do not understand their proper execution or importance. Conversely, 37 (31%) of participants are entirely unfamiliar with the term.

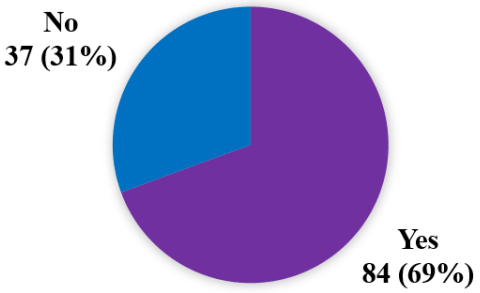

Figure 1: Distribution of study subjects who heard about pelvic floor muscle exercise during the postnatal period

Based on Table 2, of 121 participants, 59 (48.8%) participants reported a history of urinary incontinence, 53 (43.8%) participants contacted the doctors, and 68 (56.2%) did not. Fifty-nine (48.8%) sought medical treatment, 37 (30.6%) practiced Kegel exercises, and 25 (20.6%) underwent surgical interventions. Eighty-nine (73.6%) participants did not undergo any gynecological surgeries, while 32 (26.4%) did. A large portion of postnatal mothers (74.4%) reported a history of lower back pain, whereas 31 (25.6%) did not. Additionally, 85 (70.2%) of participants experienced pelvic region injuries, leaving 36 (29.8%) injury-free. Ninety-six (79.3%) of participants reported issues with constipation or frequent straining during bowel movements, while 25 (20.7%) did not. Urinary problems were also prevalent, with 93 (76.9%) of participants experiencing urinary leaks and 96 (79.3%) reporting significant bladder urgency. Regarding urinary frequency, 39 (32.2%) of mothers empty their bladders 3-4 times daily, while other frequency distributions are provided. A notable 100 (82.6%) experienced challenges in completely emptying their bladders, and 99 (81.8%) of postnatal mothers reported trouble fully emptying their bowels. Ninety-three (76.9%) mothers experienced pain or discomfort during or after intercourse. Twenty-six (21.5%) participants were unaware of the pelvic floor muscle exercise technique. This lack of knowledge raises concerns regarding the potential for future health complications, suggesting that these individuals may not be able to take preventive measures against pelvic floor health issues. However, only 31 participants (37.51%) practiced these exercises regularly, while the majority (83.49%) reported not practicing them at all.

Table 2 focuses on the attitude towards PFME among postnatal mothers. One hundred and two (84%) participants were interested in learning more about PFMEs, and 103 (85.1%) of participants emphasized the importance of educating postnatal mothers about pelvic floor muscle exercises during pregnancy.

Table 2: Knowledge and Attitude related to pelvic floor muscle exercise (n=121)

Variable	Frequency (n)	Percentage (%)
Have you ever had a previous history of urinary incontinence during the postnatal period?		
Yes	59	48.8
No	62	51.2
If yes according to the previous question, have you ever contacted the doctor		
Yes	53	43.8
No	68	56.2
If yes according to the previous question, what type of treatment was taken?		
Surgery Treatment	25	20.6
Medical Treatment	59	48.8
Follow Kegel Exercise	37	30.6
Have you ever undergone gynecological surgery?		
Yes	32	26.4
No	89	73.6
Do you have a history of lower back pain?		
Yes	90	74.4
No	31	25.6
Have you ever injured your pelvic region?		
Yes	36	29.8
No	85	70.2
Do you suffer from constipation or regularly strain on the toilet?		
Yes	96	79.3
No	25	20.7
Do you have a chronic cough or sneeze?		
Yes	94	77.7
No	27	22.3
Do you frequently lift heavy weights?		
Yes	76	62.8
No	45	37.2
Do you experience leakage of urine during daily activities?		
Yes	93	76.9
No	28	23.1
Do you experience strong bladder urgency?		
Yes	96	79.3
No	25	20.7
How many times a day do you empty your bladder?		
1-2 times	25	20.7
3-4 times	39	32.2
5-6 times	23	19.0
7-8 times	20	16.5
9-10 times	14	11.6
Do you find it difficult to completely empty your bladder?		
Yes	100	82.6
No	21	17.4
Do you find it difficult to fully empty your bowel?		
Yes	99	81.8
No	22	18.2
Have you experienced pain or discomfort during or after intercourse?		
Yes	93	76.9
No	28	23.1
Do you know the pelvic floor muscle relaxation exercise technique?		
Yes	26	21.5
No	95	78.5
If yes, do you do regular pelvic floor muscle exercises?		
Yes	31	37.51
No	69	83.49
Are you interested in learning more about PFMEs?		
Yes	102	84
No	19	16
In your opinions is it important for women to know about pelvic floor muscle exercise in pregnancy?		
Yes	103	85.1
No	18	14.9

Findings Related to Overall Knowledge and Attitude:

Table 3 demonstrated the data highlights the overall knowledge and attitude levels of 121 postnatal mothers. These percentages provide insight into the level of awareness and mindset among the participants regarding post-natal care or related topics.

- **Knowledge level:** Out of 121 participants, 78 (64.46%) had a moderate knowledge level. This suggests that nearly two-thirds of the mothers possessed a good understanding of the subject in question (e.g., post-natal care or health-related topics).
- **Attitude level:** The attitude level among participants was higher, with 87 (71.90%) exhibiting a highly positive or favorable attitude. This indicates that most of the postnatal mothers not only had knowledge but also demonstrated an encouraging mindset toward the topic.

Table 3: Overall level of knowledge and attitudes of participants (n=121)

Level	Knowledge of participants	Attitudes of participants
Low (1-33%)	-	-
Moderate (34-66%)	78 (64.46%)	-
High (67-100%)	-	87 (71.90%)

Findings related to the association between the knowledge and attitude score with selected demographic variable

The data from this study examines the relationship between various demographic factors and the knowledge and attitudes towards PFME among postnatal mothers. Most participants in the aware group believed that PFMEs could improve a wide range of pelvic floor dysfunctions. These included sexual dysfunction, pelvic pain/back pain, urinary incontinence, voiding dysfunction, pelvic organ prolapse symptoms, constipation, fecal incontinence, and overall quality of life. This highlights the widespread belief in the positive impact of PFME on both specific pelvic health issues and overall well-being.

The study found that knowledge scores about PFME were significantly associated with several demographic factors, including age, number of children, education level, residence area and monthly family income.

Attitudes towards pelvic floor muscle exercises were significantly linked to different factors, including age, religion and education level.

DISCUSSION

The results of the study have been examined in relation to the objectives, assumptions, and outcomes of other pertinent research, organized under the following headings:

Section I: Discussion of the demographic characteristics of the participants

The findings of this study indicate that the age distribution reveals that most postnatal mothers fall within the middle-aged category, specifically between 35 and 44 years. Younger age groups and teenage mothers (below 20 years) formed a smaller proportion, suggesting that motherhood at a younger age was less common in this population. Mothers aged 35 to 45 exhibit a reluctance to pursue education with ease. They are often hesitant to discuss their challenges. Consequently, it is essential to develop policies that specifically target this demographic, ensuring their active participation in a variety of educational initiatives. The predominance of nuclear families (58.7%) over joint families (32.2%) indicates a shift towards smaller family units. Additionally, the high percentage of mothers with four or more children (33.1%) reflects a trend of larger sizes. The majority of participants, comprising 41.3%, identified as Muslim, a group that frequently exhibits reluctance in seeking medical care and addressing reproductive health issues. As a result, many Muslim women in Bangladesh delay seeking medical attention until their symptoms deteriorate, causing their health problems to worsen over time. The purpose of this research work is to raise knowledge about reproductive health issues, such as pelvic floor dysfunction, among Bangladeshi mothers, as well as to promote the benefits of PFME to support proactive health management. The finding that 52.1% of mothers attained primary education, and only 7.4% achieved higher secondary levels, points to limited access to advanced education for women in this population. Most families earned a moderate monthly income (10,001-20,000 and below 10,000 taka), with fewer families earning 20,001-30,000 taka. This highlights an economic disparity within the group. A large majority (72.7%) of mothers living in urban areas indicates a concentration of the population in urban settings, potentially due to better access to healthcare and other resources.

These findings align with studies reporting higher fertility rates and larger family sizes in middle-income countries. Based on Wu et al. (2023), the majority of participants were aged between 18 and 27 years (35.9%), with a significant portion being married (71.0%) and sexually

active (83.1%). A notable percentage had not experienced pregnancies (30.3%), while others had one child (38.7%). The mode of delivery for many was vaginal (32.9%). In terms of education, 62.3% held either a bachelor's or associate degree, and 36.7% were employed in professional occupations. Most participants resided in urban areas (65.5%) and reported an income ranging from 2,000 to 5,000 (43.5%).

Section II: Discussion of assessment of knowledge and attitude on pelvic floor muscle exercise for reducing urinary incontinence and its consequences among the postnatal multiparous pregnant mothers

The study presented a significant statistical analysis: high percentages of postnatal mothers reported experiencing issues related to urinary incontinence (93, 76.9%), and a proportion of participants may benefit from pelvic floor muscle exercises and education. Despite the awareness of pelvic floor muscle exercises by 64 (69%) of the participants, the lack of understanding about their execution and significance suggests a gap in effective education. The majority, 89 (73.6%), of participants had not undergone gynecological surgery, which might indicate a younger cohort, although a significant proportion, 32 (26.4%), had. This could influence their experiences with pelvic health issues. This high prevalence percentage focuses on these problems that are often exacerbated by pregnancy, childbirth, and other physical stresses. The fact that most participants expressed a desire for education on pelvic floor exercises highlights the importance of providing accessible information and training. The discrepancy between familiarity with the term "pelvic floor exercises" 64 (69%) and a lack of understanding about their significance suggests a potential area for educational intervention. This gap may be addressed through targeted campaigns or healthcare provider training, ensuring that postnatal mothers understand not just the term but also the exercises and their long-term benefits.

The findings in this study are consistent with previous research that highlights the prevalence of pelvic floor issues among postnatal mothers. For instance, in a study by Rosediani et al. (2012), the prevalence of urinary incontinence was found to be 19.6%. Of those affected by UI, 36.6% expressed concern regarding the issue and felt the necessity to utilize some form of protective measures. Furthermore, the study by Okeke et al. (2020) emphasizes the benefits of pelvic floor muscle exercises as a preventive measure for pelvic floor dysfunction, aligning with 41.6% of participants believing these exercises help prevent urinary incontinence, 4.5% thinking they prevent fecal incontinence, 62.0% asserting that they enhance sexual function, and 1.6% indicating that they lower the risk of pelvic organ prolapse.

Section III: Discussion of Overall Knowledge and Attitude Score

The data shows a higher percentage of participants (71.90%) with a positive attitude compared to those with moderate knowledge, 78 (64.4%). This could suggest that, while some post-natal mothers may lack detailed knowledge, they still hold positive perceptions or are open to learning and engaging with relevant practices. While the majority demonstrated moderate knowledge and attitude, a significant portion of participants (35.54% for knowledge and 28.10% for attitude) fell short, pointing to potential gaps in awareness and mindset. The findings reflect an encouraging trend where most post-natal mothers have a moderate level of knowledge and a favorable attitude. Bridging the knowledge gap could further reinforce these attitudes and lead to better practices or behaviors.

These results align with studies emphasizing the critical role of education and awareness in maternal health. Wu et al., 2023) reported that the percentages of participants exhibiting moderate knowledge, a positive attitude, and good practice are 36.5% (184 out of 504), 36.1% (182 out of 504), and 33.3% (168 out of 504), respectively.

Section IV: Discussion of association between the knowledge score of postnatal multiparous pregnant mothers at selected hospitals with demographic variable

The significant correlations between knowledge scores and factors such as age, number of children, education level, residence area, and monthly income suggest that older, younger, more educated individuals with higher income levels and more children may have a greater awareness of PFME. Additionally, those living in urban areas may have greater access to resources and information about PFME, leading to better knowledge.

The significant associations between attitude scores and age, religion, and education level suggest that individuals with certain demographic characteristics may have more positive or open attitudes towards PFME. For instance, older mothers may have a greater appreciation for the importance of pelvic health, and those with higher education may be more receptive to scientific health information. Religious beliefs might also influence personal health practices and attitudes toward exercise.

Overall findings suggest that many post-natal mothers in the aware group understand the comprehensive benefits of PFME, indicating a high level of awareness regarding its

potential to address a wide variety of pelvic health issues. However, the study also reveals that knowledge of PFME is influenced by specific demographic factors, such as age, education levels and family income. These factors likely determine access to health information and resources, highlighting the need for targeted interventions to increase awareness in underrepresented groups, especially those with lower education levels, lower incomes, or in rural areas.

Furthermore, attitudes towards PFME appear to be influenced not only by demographic factors like education and age but also by religion, suggesting that cultural and personal beliefs can play a significant role in shaping individuals' perceptions of pelvic health and exercise. This implies that health education programs should consider these factors to be more effective.

These results align with previous studies that have explored the factors influencing mothers' health behaviors. In a study by Wu et al., (2023) the knowledge scores were notably elevated among patients aged 28 to 33 years, particularly those with higher education levels, engaged in professional occupations, residing in urban settings, possessing a relatively high income, and who identified as non-drinkers and non-smokers. Additionally, these individuals had been diagnosed with pelvic floor dysfunction, although they had not yet received treatment. Similarly, a study by Temtanakitpaisan et al. (2020) found that pregnant women believed the PFMT had beneficial impacts on their health, including enhancements in incontinence, pelvic organ prolapses, overall quality of life, and heightened sexual satisfaction.

This research was carried out utilizing a validated questionnaire aimed at examining knowledge and attitudes towards the impact of PFME on improved outcomes and pelvic floor function. Given that this was a cross-sectional study, we focused solely on compliance and did not assess the techniques of PFME, which constitutes a limitation of our investigation.

CONSIDERATION, LIMITATION AND RECOMMENDATION

The study's data are specified to 121 postnatal multipara mothers, which may not fully represent the broader population. The income categories and educational levels lack detailed granularity for deeper analysis. Factors such as cultural or regional differences are not explored.

Investigate the impact of urbanization on family health and childbearing trends. Explore barriers to higher education for women in semi-urban and rural areas. Analyze the relationship between family income and access to maternal healthcare. Further research should explore the effectiveness of tailored education programmes that consider the demographic and cultural factors influencing knowledge and attitudes towards PFME. Studies could investigate the role of healthcare professionals in educating mothers about pelvic health and whether personalized, culturally sensitive counseling improves the adoption of PFME. Additionally, research could examine long-term outcomes of PFME intervention on pelvic health and overall quality of life for postnatal mothers.

CONCLUSION

This study provides valuable insight into the pelvic health challenges faced by postnatal mothers and the knowledge and attitude gaps related to pelvic floor muscle exercises. Despite a high awareness of the term, the lack of understanding regarding its significance calls for increased educational efforts. Addressing pelvic health through education, particularly during pregnancy, could help alleviate common issues such as urinary incontinence, lower back pain, and pelvic injuries, thus improving maternal well-being. The perceived benefits of PFME for a wide range of pelvic health issues highlight its potential as a valuable intervention. However, the study also identifies significant factors-such as age, education, religion, and family income—that influence both knowledge and attitudes. These factors must be considered when designing educational programs to ensure that they have the resources they need to improve their pelvic health.

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ORIGINAL ARTICLE

Hyperacusis Among Adults With Occupational Noise Exposure

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ABSTRACT

Background: Hyperacusis is characterized by increased sensitivity and reduced tolerance to sounds, which most people find acceptable. This research effort addresses this critical gap in understanding the role of occupational noise exposure as one of the contributing factors of hyperacusis. In addition, the study aims to adopt the modified Hyperacusis Questionnaire as a valuable tool for early identification of hyperacusis in an adult population. This study aims to determine the occurrence of hyperacusis in adults who are exposed to occupational noise. **Methodology:** A cross-sectional study was conducted using a convenience sampling technique. A total of 95 workers in Malaysia participated. Data was collected using the modified Khalfa Hyperacusis Questionnaire, which was developed by Khalfa, in 2002. **Results:** Most workers (57.9%) are not well informed regarding the existence of hyperacusis. Hyperacusis was observed in 95.6% of individuals who were exposed to noise in the workplace, while only 4.4% of participants reported having normal sound tolerance. A Mann-Whitney U test showed no significant difference in awareness of hyperacusis between adults with occupational noise exposure and those without occupational noise exposure ($p=0.62$). **Conclusion:** The findings highlight a considerable gap in workers' awareness regarding hyperacusis. This underscores the need for education and occupational safety regulations to enhance workers' awareness and management of noise in the work environment to create conducive working spaces for them.

INTRODUCTION

Hyperacusis is a rare loudness perception disorder that occurs either unilaterally or bilaterally with an estimated 8% of Swedish individuals having hyperacusis (Andersson et al., 2002; Fredriksson et al., 2022; Paulin et al., 2016). The condition may manifest in individuals with either normal hearing or hearing loss (Fackrell et al., 2017).). Hyperacusis is also defined as hypersensitivity and reduced tolerance to ordinary environmental sounds that would normally be considered as non-intrusive to most people (Fredriksson et al., 2022a). While nearly all cases of hyperacusis are bilateral in nature, the disorder is often associated with significant discomfort triggered by suprathreshold sounds or exceptionally low hearing thresholds. To further expand the concepts of hyperacusis, Tyler et al. (2015) categorized the concepts into four; (1) loudness hyperacusis; (2), pain hyperacusis; (3), fear hyperacusis; and, (4) annoyance hyperacusis.

The impact of hyperacusis on a person can vary from slightly bothersome to incapacitating. Due to avoidance behaviour that results in self-isolation and elevated stress levels, adults with hyperacusis may suffer from sleep disturbances, social anxiety, poor emotional well-being, anxiety, and difficulties concentrating (reference). Nunez (2021) listed a number of potential causes of hyperacusis, including viral infections, autoimmune diseases, head trauma, extreme noise exposure, and emotional stressors like PTSD. Although hyperacusis can have many different diagnoses and aetiologies, numerous studies have found that noise exposure is the most common cause (Fredriksson et al., 2022a). It has been a major concern for people working in noisy workplaces, particularly in industry and manufacturing.

According to Shehabi, Pendergast, Guest, and Plack (2023), exposure to noise at work is linked to a number of auditory symptoms, including tinnitus, hyperacusis, noise-induced hearing loss (NIHL), and temporary threshold shifts, in addition to non-auditory symptoms like high blood pressure, cardiovascular disease, and stress. Taking this matter into consideration, various developed countries have implemented different maximum permissible occupational noise exposure levels (Shehabi et al., 2023; Shaikh, 1999). Locally, the permitted noise exposure limit (PEL) in Malaysia is 85 dB(A) or a daily personal noise dose of 100%, as determined by the Occupational Safety and Health (Noise Exposure) Regulations 2019. Additionally, the maximum sound pressure level should not exceed 115 dB(A), and the peak sound pressure level should remain below 140 dB(C) (Department of Occupational Safety and Health, 2019).

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According to Jahn's (2022) research, hyperacusis affects 8.6% to 15.2% of people, according to population-based data. Tyler et al., (2014), argued that distinct symptom characteristics could separate four categories of hyperacusis: loudness, pain, irritation, and terror (Fredriksson et al., 2022). Aetiology and symptoms are the determinants of its treatment. Since most hyperacusis sufferers report having tinnitus, typical treatments for hyperacusis include cognitive behavioural therapy (CBT), tinnitus retraining therapy (TRT), sound desensitisation, therapies including yoga and acupuncture, and surgery. (Coey, 2020; Nunez, 2021).

Many workers are unaware of the health risks associated with extended exposure to loud noise since the negative consequences of noise pollution take a long time to become apparent. Therefore, to understand and further elaborate on the scenario of hyperacusis in Malaysia, this study aims to study the existence of hyperacusis among adults who are exposed to occupational noise using a Modified Khalfa Hyperacusis Questionnaire, in a large group of randomly selected adult workers. By understanding the intricate interplay between noise exposure at work and hyperacusis, this research also helps to provide valuable insights into the early detection of hyperacusis in order to provide immediate and appropriate treatment for those who may be unaware of their reduced tolerance towards ordinary environmental sounds.

The aim of this study was to study the existence of hyperacusis among adults who are exposed to occupational noise. Specifically, this study aims:

i. To investigate the awareness about the existence of hyperacusis or reduced tolerance toward sound among workers who are at risk of occupational noise exposure.
ii. To investigate the existence of hyperacusis among Malaysian workers who are exposed to occupational noise with Modified HQ scores.
iii. To compare the level of hyperacusis between workers who are exposed and not exposed to occupational noise exposure using Modified HQ scores.

MATERIALS AND METHODS

Study Design

This study adopted a cross-sectional observational study design. Questionnaires were distributed to workers who met the inclusion criteria. This research strategy was chosen due to its ease of administration and cost-effectiveness.

Sampling Technique

The chosen sampling techniques were convenience and purposive sampling. The participants were selected randomly following their willingness and availability to participate in the study by responding to the MHQ form that was sent out as a hard copy and through a Google Form that was sent over a personal messaging app.

Study Population and Sample Size

Ninety-five workers who are at risk of occupational noise exposure, aged 18 to 60 years old were recruited, selected via convenience sampling from a number of Kuantan industrial and non-industrial firms; the sample size was determined to be 76%. Oil and gas processing, electronics manufacturing, polymer synthesis, and chemical manufacture are examples of industrial factories. (International Labour Organization, 2022). However, printing and publishing companies, textile manufacturers, food processing facilities, and assembly plants are examples of non-industrial factories (International Labour Organization, 2022).

The inclusion criteria for the participants were:

1. Currently employed in industries or job roles that involve potential or known occupational noise exposure.
2. Age ranging from 18 to 60 years old.
3. Ability to read and understand English fluently.

The following additional inclusion criteria were made applicable to participants who were chosen for the study's second goal, that is to determine if Malaysian workers who are exposed to noise at work have hyperacusis:

1. Exposed to occupational noise for a minimum duration of 1 year and more
2. Regularly exposed to noise levels exceeding 85 dBA for 8 hours and more.

Location

The questionnaire was distributed using two methods, physical face-to-face administration and as an online survey. For the physical face-to-face administration, the hard-copy questionnaire was distributed to; (1) workers at the Polyplastics facility in Balok, Kuantan; and (2) patients in IIUM Hearing Clinic in Jalan Hospital Building (JHB). For the online survey, the questionnaire was distributed widely through personal communication application using Google Form.

Instrumentation

The study used a Modified Khalfa Hyperacusis

Questionnaire (MHQ) that was developed by Khalfa, Dubal, Veuillet, Perez-Diaz, Jouvent, & Colletin 2022., comprising two parts, participant information and questionnaire items with a 3 point- scoring level ranging from "no" (scoring 0 points), "sometimes" (scoring 2 points), to "yes" (scoring 5 points) (Am Alkharabsheh A-F & Alaqrabawi, 2021). This questionnaire consisted of 20 self-rating items isolated into three dimensions: 1) functional (questions 1–7, total score 0–35), social dimension (questions 8–13, total score 0–30), and emotional dimension (questions 14–20, total score 0–35). respectively. The possible total index score was 100 and the severity of the hyperacusis was determined based on the total score.

Data Collection

The data was gathered over a three-month period. An informed consent form and research information sheet was included in the first page of the form to ensure the participants have a clear understanding of their involvement. Participants were required to read and sign the informed consent form to signify their voluntary agreement to participate in the research. Alongside the consent form, the questionnaire was included in the next page of the form. Clear instructions were provided for participants to accurately complete the questionnaire. The subjects were asked to provide their name, age, and gender for recording purposes and to obtain basic participant information.

Following data collection, all study participants were divided into two groups based on their responses to an extra question on their history of overall job exposure: 1) An experimental group for employees exposed to noise at work, and 2) A control group for employees not exposed to noise at work.

Data Analysis

In this study, IBM SPSS Version 20 was used in the analysis of the quantitative data. By analysing the survey data, quantitative analysis was used to calculate the frequency and percentage. Then, all relevant tables were interpreted in reference to the study's objectives.

RESULTS

A total of 95 completed surveys were collected: 44 males (46.3%) and 51 females (53.7%). The age of participants ranged from 20 to 59 years old. As in Table 1, the majority of the age group participating in the study were young adults, ranging from 20 - 31 years old. Conversely, older adults who are 60 years and above were excluded due to health and comorbidity considerations. Older aged adults are more likely to have age-related health conditions and comorbidities that can influence their experience and reporting of hyperacusis symptoms. Forty-nine participants (51.6%) reported as having the risk of exposed to occupational noise and 46 participants (48.4%) reported of not having any risk being exposed to occupational noise. History of exposure to occupational noise was the independent variable of the study. Occupational noise exposure history was collected by asking participants to report, in free text, every occupation and the working nature they had ever held throughout their working life.

Table 1: The demographic of respondents

Variable	Mean (*SD*)	*n* (%)
Age (years)	1.35 (0.50)	
Young adults		63 (66.3)
Middle-aged adults		31 (32.6)
Old adults		1 (1.1)
Gender	1.46 (1.00)	
Male		44 (46.3)
Female		51 (53.7)
Noise Exposure	1.48 (0.50)	
Yes		49 (51.6)
No		46 (48.4)

Objective 1

Table 2: The awareness about the existence of hyperacusis or reduced tolerance toward sound among adults

Variable	n	Percentage (%)
Awareness of hyperacusis		
Yes	40	42.1
No	55	57.9
Are you familiar with hyperacusis (reduced tolerance towards sound)?		
Yes	11	11.6
No	84	88.4

Based on the data, 42.1% of participants were aware of hyperacusis, and of those, only 11.6% were more knowledgeable about how the decline in sound tolerance may affect their quality of life. On the whole, this result indicates that most of workers in Malaysia are not sufficiently knowledgeable on the existence of hyperacusis or reduced tolerance toward sound.

Objective 2

Table 3 shows the total number of participants and its percentage based on the severity. Severity of hyperacusis was further described by the categorization of total score MHQ into 4 levels; normal (0 to 10), mild (12 to 40), moderate (42 to 60) and severe (>62) (Abdul et al., 2022). Among the 46 participants, a significant percentage (95.7%) demonstrated varied degrees of hyperacusis.

Specifically, 63% of participants had mild hyperacusis, while 19.6% and 13% were categorised as having moderate and severe hyperacusis, respectively. 4.3% of participants did not exhibit hyperacusis, suggesting that prolonged exposure to noise levels at work may be one of the causes contributing to participants' hyperacusis.

Table 3: Occupational Noise Exposure. The existence of hyperacusis among Malaysian adult workers who are exposed to occupational noise with Modified HQ scores (n: 46)

Score	Degree	N (%)
0 - 10	Normal	2 (4.3)
12 - 40	Mild	29 (63.0)
42 - 60	Moderate	9 (19.6)
62 - 100	Severe	6 (13.0)

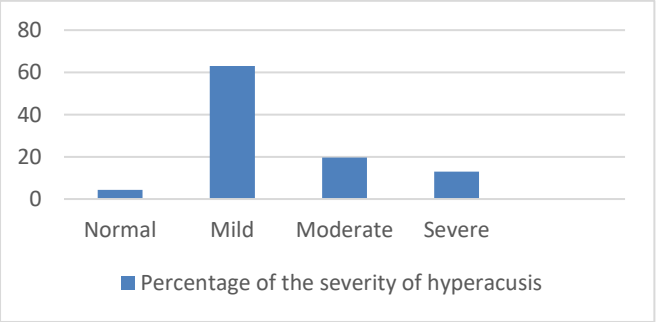

Figure 1: Percentage of the severity of hyperacusis

Figure 1 shows that most of the subjects participating in this study reported having mild hyperacusis indicating that sound tolerance is a common problem seen in occupational noise exposure workers, especially youngsters.

Objective 3

Shapiro-Wilk test revealed that the data was not normally distributed. Therefore, the Mann-Whitney U test (non-parametric) was performed to determine the influence of work history between these 2 groups and the total MHQ scores.

Table 4: Mann-Whitney U Test comparing the level of hyperacusis by calculating the total Modified HQ scores between adults with occupational noise exposure and without occupational noise exposure (n = 95)

	Level of hyperacusis	
	Occupational Noise Exposure	Non-occupational Noise Exposure
N	49	46
Mean	42.55	53.11
Mann-Whitney, U	-1.869	
Sig. difference, *p*	0.62	

Table 4 presents the comparing the level of hyperacusis by calculating the total Modified HQ scores between occupational and non-occupational job exposure. Results showed that Group 1 (occupational noise exposure) with a sample size of 49 and a mean rank of 42.55 and Group 2 (non-occupational noise exposure) with a sample size of 46 and a mean rank of 53.11. The Mann-Whitney value is -1.869 while the *p*-value is 0.62, suggesting that there is no significant difference in total Modified HQ scores between these two groups of workers.

DISCUSSION

Awareness of Hyperacusis

Hyperacusis, an abnormal sensitivity to everyday sound levels that are not uncomfortable to others, remains significantly under-recognized in the workplace. Although there is little awareness among companies and employees, noise exposure is a major contributor to hyperacusis and can have a serious negative influence on people's productivity and quality of life.

As shown in Table 2, the awareness of hyperacusis is still lacking among industry workers, with 42.1% of the participants were unaware of hyperacusis. One primary reason for the low awareness of hyperacusis in industrial environments is its subtle symptoms. Unlike more obvious occupational hazards such as chemical exposure or physical injuries, hyperacusis symptoms can be easily overlooked or incorrectly attributed to other causes. Consequently, affected individuals might suffer in silence, unaware that their discomfort is due to a legitimate medical condition. Furthermore, hyperacusis often coexists with other auditory issues such as tinnitus or hearing loss, further complicating its diagnosis and management. This overlapping symptom can lead to misdiagnosis or inadequate treatment, perpetuating the lack of awareness around hyperacusis.

Another contributing factor is the lack of education and training among employers, occupational health professionals, and workers. Unlike more well-known conditions such as noise-induced hearing loss or tinnitus, hyperacusis is rarely addressed in workplace health programs. Employers may ignore the need for noise control or accommodations, causing ongoing discomfort for affected employees.

Addressing the low awareness of hyperacusis in workplaces requires a multifaceted approach involving education, policy changes, and cultural shifts. Employers should prioritize noise management strategies, conduct regular assessments of noise levels, and provide accommodations for employees with hyperacusis. Training

programs should include information on recognizing, preventing, and supporting hyperacusis to create an inclusive and supportive work environment.

The existence of hyperacusis among Malaysian adult workers who are exposed to occupational noise with Modified HQ scores

The primary finding of this study is the significantly increased risk of hyperacusis among adults working in occupational noise exposure, objectively assessed using the total HQ scores, compared to those with non-occupational exposure. The Modified Hyperacusis Questionnaire is a screening tool that can be used for early identification of hyperacusis in the adult population. The results revealed that more than half of the noise-exposed participants were reported having hyperacusis. Our sample mostly included people who are at risk of developing hyperacusis, such as industrial workers, and most of them were males. Only 4% of the participants had normal sound tolerance/ no hyperacusis. This result revealed that this group's occupation consists of officers and process technicians who answered "no" for both questions of "Do noise levels prevent conversation with co-workers in a normal voice level when at work?" and "Is a raised voice needed to communicate with someone about one meter away?". Therefore, we can conclude that both workers were not directly in contact with the noise at their work that can lead to hyperacusis.

Noise-induced auditory conditions such as hyperacusis typically exhibit a gradual onset rather than sudden occurrence. Occupational noise exposure can initially induce mild hyperacusis, marked by discomfort in response to moderately loud noises, which may not significantly impede daily activities. Continued exposure to high noise levels can cause some individuals to develop moderate to severe hyperacusis, characterized by substantial distress and functional impairment. However, the progression to severe stages is not universal and is contingent upon factors like the intensity and duration of noise exposure, the use of hearing protection, and individual biological susceptibility (Baguley, 2003). Research indicates that prolonged exposure to excessive noise can result in auditory hypersensitivity due to alterations in central auditory processing, notably within the auditory cortex and brainstem. These neurophysiological changes may account for the higher prevalence of mild hyperacusis compared to the fewer cases of severe symptoms (Fredriksson et al., 2021).

Different people react differently to noise, which is why the severity of hyperacusis varies between workers. Whether someone develops mild, moderate, or serious hyperacusis could be based on whether they have any hearing problems and how their brain processes sounds differently. Underlying neurological conditions like migraines or tinnitus have been associated with higher sound sensitivity and may make hyperacusis worse (Tyler et al., 2014). Subsequently, psychological factors such as anxiety and stress can also exacerbate hyperacusis symptoms given that strong emotional responses lead to higher sensitivity towards sound (Aazh et al., 2018). As a result, while most workers exposed to occupational noise develop only mild hyperacusis, a smaller proportion progresses to moderate or severe cases due to these individual differences in auditory susceptibility.

Level of hyperacusis between adults with occupational noise exposure and without occupational noise exposure using Modified HQ scores

The assumption that one's working environment, especially in noisy environments, directly influences the development and severity of hyperacusis is not strongly supported by research and clinical observations. This study also revealed that there is no significant difference in the existence of hyperacusis between those with and without occupational noise exposure with among the workers.

Several factors contribute to the absence of a clear association between occupation and hyperacusis, including individual susceptibility, non-occupational noise exposure, and occupational safety measures. The variability in individual susceptibility to hyperacusis means that not all individuals working in noisy environments develop hyperacusis. One possibility is that chronic exposure to noise leads to a form of auditory adaptation, effectively lessening workers' sensitivity to loud sounds. This desensitization, rather than sensitization, could account for the unexpected results. Furthermore, a "healthy worker effect" may be at play. Individuals with heightened noise sensitivity might self-select out of noisy occupational environments. This potential selection bias could skew the composition of the exposed group toward those more resilient to hyperacusis.

Secondly, it is also important to acknowledge that the non-exposed group may encounter other stressors, both auditory and psychological, that could contribute to hyperacusis. Factors such as sudden loud noises, high-pressure work environments, or mental fatigue, though distinct from sustained occupational noise exposure, could influence their reported hyperacusis scores. Further research is needed to disentangle these complex interactions and gain a clearer understanding of the relationship between noise exposure and hyperacusis.

Thirdly, hearing loss within the exposed group could contribute to lower hyperacusis scores. While seemingly

contradict, hearing loss often a consequence of prolonged noise exposure which can lessen the sensitivity to lower intensity sounds, potentially masking hyperacusis symptoms (Fredriksson et al., 2021; Sheppard et al., 2020). Therefore, while they may still experience hyperacusis, its perceived intensity decreased due to the underlying hearing loss (Baguley, 2003; Plack et al., 2014). However, the relationship between hearing loss and hyperacusis is complex and yet to be fully understood (Baguley, 2003). While they may co-occur, one does not necessarily cause the other. Further research incorporating audiometric testing and psychosocial assessments is needed in order to gain more input on the relationship between noise exposure and hyperacusis existence.

CONCLUSION

In conclusion, while there is a general awareness among workers regarding hyperacusis, there is a clear need for more targeted efforts to enhance this understanding and promote consistent noise reduction practices at work environment. This underscores the need for education and occupational safety regulations to enhance workers' awareness and management of noise in the work environment to create conducive working spaces for them.

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THE IMPLICATION OF THE STUDY

The research can be the basis for public health campaigns and educational initiatives aimed at raising awareness of employers who are routinely exposed to loud environments to implement better hearing protection practices. This study also may stimulate further research in the field, encouraging the exploration of and a deeper understanding of hyperacusis. Besides, this study is believed to become a turning point to initiate training and workshops for employees in Malaysia to enhance knowledge regarding risk of hyperacusis.

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ORIGINAL ARTICLE

Content Validation of the KhAIR rubric, a Value-Driven Rubric for Health Science Students

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ABSTRACT

Background: As education in Malaysia is becoming more holistic, an accurate, trustworthy, and useful assessment of students' qualities is required to guarantee a fair assessment of students. This study aimed to develop and validate a rubric to evaluate four student value-driven attributes, *Khalīfah, Amānah, Iqra' and Rahmatan lil- 'Alamin* (KhAIR), which is highlighted in the International Islamic University Malaysia's Sejahtera Academic Framework. **Methods:** Following the initial rubric construction, content validation was conducted through expert interviews with six subject matter experts and measured using the analysis of content validity index (CVI) and content validity ratio (CVR). **Results:** The final version of the KhAIR rubric includes four main attributes and 16 sub-attributes. Its content validity improved significantly between the pre- and post-discussion sessions with the experts ($S\text{-}CVI_{Relavance}$: pre=0.99, post=1.00; $S\text{-}CVI_{Clarity}$: pre=0.90, post=0.98; $CVR_{Essential}$: pre=0.90, post=1.00). **Conclusion:** This study highlights the complexity of producing a value-driven rubric that is founded in Islamic teachings and values. Nevertheless, the development of this rubric revealed that it is possible to establish and align institution-specific value-based rubrics in health sciences. Despite showing good content validity, further research is needed to assess its reliability and applicability in the various fields of the health sciences.

INTRODUCTION

Modern education focuses on preparing students and graduates for an increasingly competitive global marketplace, where the demand for interpersonal and cognitive abilities is rising. As the global economy shifts from general labor-driven industries to those powered by technological innovations (Ontario's Global Competencies, 2014), educational system is adapting to meet these new workforce demands. While the importance of these human-centred skills is widely recognized across regional, national, and global educational institutions, a definitive list of specific skills or attributes remains less established. In Malaysia, the National Philosophy of Education emphasizes the importance of developing students who are not only knowledgeable and competent, but also socially, spiritually, emotionally, and physically balanced (MOE, 2019). These attributes are crucial for fulfilling their roles as workforce professionals and responsible Malaysian citizens. The initiation of a high-quality graduate program marks the primary shift in the National Education Blueprint (2015-2025), aiming for continued excellence in Malaysia's higher education system, particularly in addressing graduate employability challenges. The blueprint outlines six primary graduate attributes: knowledge, leadership and thinking skills, language proficiency, ethics, spirituality, and national identity that are incorporated into all aspects of students' teaching and learning experiences (MOE, 2013). Founded with a focus on incorporating Islamic principles into its academic programmes, the International Islamic University Malaysia (IIUM) has established the Sejahtera Academic Framework (SAF) that is consistent with the aims of the National Education Blueprint. The SAF serves as a guideline for planning, designing, and maintaining high-quality academic programmes to nurture a well-balanced and harmonious student, also known as *Insan Sejahtera* (Borhan et al., 2021). The IIUM's SAF defines *Insan Sejahtera* as an individual who possesses the four main core elements or attributes of *Khalīfah*, *Amānah*, *Iqra'* and *Rahmatan lil- 'Alamin* or KhAIR. In Arabic, KhAIR means 'good,' a concept repeatedly emphasized in many Quranic verses, prescribed as a mission for all human beings, including students and graduates (Borhan et al., 2021). These attributes collectively nurture a balanced individual who is ethical *(Amānah),* knowledgeable and reflective *(Iqra'),* responsible for societal and environmental stewardship *(Khalīfah),* and driven by a purpose of

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universal mercy *(Raḥmatan lil-ʿĀlamīn).* The SAF (Borhan et al., 2021) derived these attributes from the Islamic worldview and Quranic principles and aligned it with the University's Mission and Vision, as well as the objectives of the *Maqāṣid Ash-Sharīʿah*, which focuses on the preservation of faith, life, intellect, lineage, and wealth. These attributes serve as a framework for the holistic development of IIUM graduates, ensuring their readiness to lead and serve in a rapidly changing world while maintaining both spiritual and practical dimensions of human development. The KhAIR attributes are unique as it highlights the importance of tawhidic epistemology which is in harmony with good character instead of isolating each value as a solitary and fundamental skills as seen in the iCGPA rubric (MOHE, 2016) and the AAC & U Value Rubrics (Rodriguez & Fekula, 2019). In Islamic theology, Allah SWT Created all things and has preordained outcomes for all His creations (Quran 25:2), therefore every attribute and circumstances in life must be attributed to Him. The KhAIR attributes serve as ontological markers of human purpose and societal guidance, not only within Islam but as universal moral archetypes. This stands in contrast with "modern" anthropocentrism, where man is autonomous and self-legislating such as the Kantian-humanist view (Minson, 1989). The Islamic paradigm defines man as dependent-yet-dignified, with purpose bound to Allah's Will.

Table 1 shows the definitions of *Khalīfah*, *Amānah*, *Iqra'* and *Rahmatan lil- 'Alamin*. These definitions clearly show that the list of IIUM graduates' attributes firmly uphold the tawḥīdic principle (Borhan et al., 2021). This principle is unique and not observed in other 21st century skills or attribute lists. Nevertheless, IIUM and other education institutions have similar graduate attributes, which can be classified into cognitive, interpersonal, and intrapersonal clusters. Cognitive attributes refer to mental abilities to receive, process, organize, remember and respond to information, which becomes knowledge. These abilities include problem-solving and critical thinking. Interpersonal attributes are abilities to interact and communicate with others, such as teamwork, communication, and social skills. Furthermore, intrapersonal attributes refer to an individual's internal abilities to manage their emotions, feelings, and thoughts, including self-confidence and time management (Koenig, Council & Council, 2011).

Assessing students' attributes is critical to educational assessment as it strives to nurture well-rounded individuals. Generally, educational assessment is a process of systematic collection and analysis of empirical data to monitor, evaluate, and improve the student learning process (Erstad, 2010). The assessment of the students' attributes can be either formative (i.e., throughout the course), summative (i.e., at the end of the course), or both. Cognitive attributes are associated with knowledge and are usually measured using well-established and validated standardized assessments. Non-cognitive attributes, on the other hand, are always measured using self-, peers- or expert ratings rather than standardized assessments (National Research Council, 2012). In addition, other types of assessments, such as portfolios, performance- and situational-based tasks, and criterion- and standard-reference-based tasks, may also be used to assess students' attributes (Aghazadeh, 2019). Malaysian Qualification Agency recognizes the need for the inclusion of value-based education (VBE) as it has enforced compulsory application of VBE for undergraduate programmes (MQA, 2025)

Table 1: Definitions of KhAIR by the Sejahtera Academic Framework (Borhan et al., 2021)

KhAIR Attribute	Definition
Khalīfah	A *khalīfah's* role is to lead humankind to the right path of Allah which is al-*ṣirāṭ al-mustaqīm* as well as to become an exemplar to others. All human beings regardless of their beliefs and religions are appointed as *khalīfah*. One of the important tasks for *khalīfahs* to do then is the '*imārat al-kawn* (construction of the universe), to administer, manage, develop, and flourish
Amānah	The world is an *amānah* that Allah has given humankind to be fulfilled, bringing peace and harmony to the world. *Amānah* is also an adjective to describe our graduates who are ethical, trustworthy and conscientious in executing their responsibilities in any sphere of life.
Iqra'	The pursuit of knowledge in the name of Allah is sacred. The learners who fulfil the *amānah* of knowledge become scholars, who should be the inheritors of the prophets. *Iqra'* is not just about being knowledgeable in a specific area of study, but this attribute also pertains to one who expands on the culture of *iqra',* spreading knowledge to others, and imparting hikmah wisdom.
Raḥmatan lil-ʿālamīn	Essentially, this attribute speaks to the nature of the graduates who affect change and advancement in humanity via the knowledge, wisdom, and skill sets that they have gained. IIUM graduates aim to do good, and will do good, to all people regardless of creed; and to do good for all the worlds - nature, animals and the built environment

Despite its mission and vision of training students towards developing holistic qualities, the IIUM does not have a valid and reliable tool to assess non-cognitive students attributes as stated in the IIUM SAF. This paper aimed to develop and conduct a content validation of a rubric which can be used in both formative and summative assessments to evaluate students' achievement of the KhAIR attributes. The development of standardized rubric is essential in the training of allied health professionals who require set soft skills to deal with patients and other health professionals effectively. While this paper specifically focuses on the content validity of the rubric, subsequent stages of the research examine its reliability and construct validity to provide a comprehensive evaluation of the tool, and is presented in other papers.

MATERIALS AND METHODS

This study focused on developing and validating the KhAIR rubric through a mixed method with a sequential exploratory design. It was carried out in two phases, between August 2022 and August 2023. Ethical approval was obtained from the IIUM Research Ethics Committee (Human) (IREC 2022-149). Phase 1 involved the qualitative method while the quantitative method was applied in Phase 2. Figure 1 shows the process flow of rubric development.

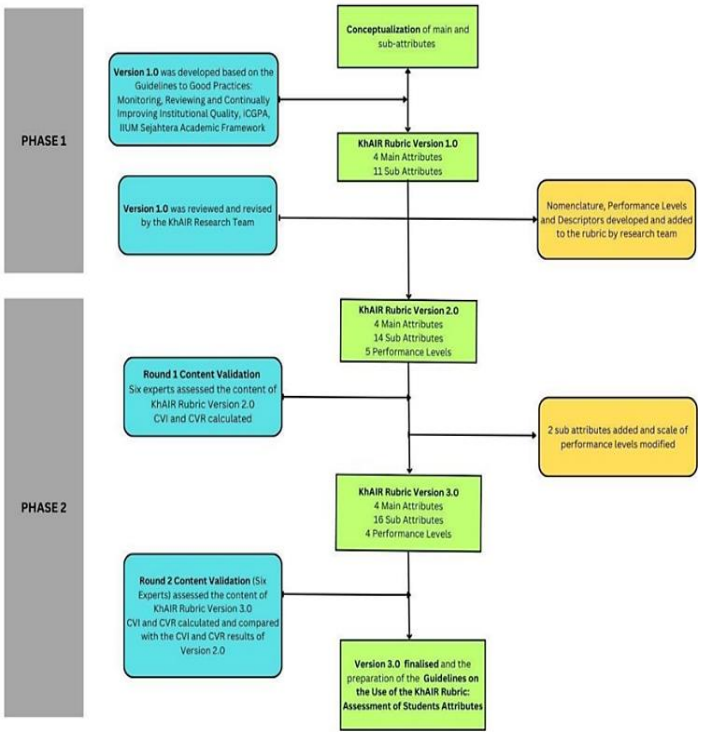

Figure 1: Schematic diagram of the development of the KhAIR rubric from its conceptualization (Phase 1) and the content validation (Phase 2).

Phase 1: Development of the Rubric to Assess KhAIR

Three key publications were referred to formulate the KhAIR rubric Version 1.0, including the IIUM Sejahtera Academic Framework (Borhan et al., 2021), the Guidelines to Good Practices: Monitoring, Reviewing and Continually Improving Institutional Quality (MQA, 2016)], and the iCGPA (MOE, 2016). The iCGPA is a reference for Malaysian academics when implementing constructive alignment in their teaching and assessment methods to meet course learning outcomes. These documents were used to draw out the relevant KhAIR sub-attributes using four main criteria: relevance, quantifiability, and consistency with the IIUM mission and vision. The sub-attributes of the first version of the rubric were then discussed with academics of the Kulliyyah (faculty) in several sessions to retrieve feedback and discuss possible applications. The research team then developed the KhAIR rubric Version 2.0 by consensus, which comprised the following five elements:

i. **Evaluation Criteria**. The rubric was composed of 14 criterions for evaluating KhAIR attributes in students' work. For example, 'Teamwork' is defined as the "ability to work synergistically in a team to foster good relationships and working together effectively").
ii. **Nomenclature**. Each sub-attribute was labelled with a specific name that reflects the evaluation criteria given.
iii. **Performance Levels**. The rubric adopted five performance levels according to their suitability for each sub-attribute (i.e. 1-Beginning, 2-Developing, 3-Sufficient, 4-Proficient, 5-Exemplary).
iv. **Performance Level Descriptors**. All performance levels are clearly described and reflect their differences. For example, 'Exemplary' is defined as "Able to foster good relationships and work together effectively with other group members towards goal achievement and beyond expectation").
v. **Grading Strategy**. The rubric incorporated a quantitative rating for each sub-attribute and performance level, making it possible to form an analytic (sub-attribute by sub-attribute, assigning to each a score between 1 and 5), and holistic (sum of all the scores obtained on all sub-attributes, with a range of 14 to 70) rating of the student's performance in their assessment.

Phase 2: Validation by the Panel of Experts

Six (6) subject matter experts were recruited to study the content validity of Version 2.0 of the KhAIR rubric. The

subject matter experts were selected based on their knowledge about KhAIR, the IIUM SAF, and their experience in academic assessment methods. Considering these criteria, three professors, two associate professors and one assistant professor specializing in medical education, rubric development and Islamic Studies were recruited across four faculties, with over 15 years of teaching experience and experience in student supervision and assessment methods. The experts were invited via personal interview, phone, or e-mail. After their acceptance, the experts received an introductory letter consisting of research background, objectives, and methodology, informed consent, and a non-disclosure agreement form.

The validation of the rubric involved two rounds: (1) Round 1 - Pre-discussion Validation, and (2) Round 2 – Post-discussion validation. In Round 1 (Pre-discussion Validation), the KhAIR rubric Version 2.0 was e-mailed to the experts with two content validation forms for their written quantitative assessment of the five elements described previously. In the Evaluation Criteria form, the experts were requested to rate each main and sub-attribute, and its descriptors with regards to clarity ("not clear", "item needs some revision", very clear), relevance ("not relevant", "somewhat relevant", "quite relevant" and "very relevant") and essential ("essential," "useful, but not essential," or "not necessary."). The experts were also allowed to give written comments and recommendations for improvements regarding the nomenclature, phrasing and terminology used for each evaluation sub-attribute.

In the Performance level and Grading Strategy form, the experts were requested to quantitatively score the clarity of each sub-attribute regarding the labelling of each performance level (1-5), performance level descriptions and suitability of the grading strategy of the rubric. The experts were also allowed to give written comments and recommendations for improvements regarding the nomenclature and phrasing used for each evaluation sub-attribute. Following the experts' quantitative assessment, they were also invited to a group discussion to allow them to clarify their feedback, express their opinion and suggestions on the rubric with regards to:

i. The rationale behind their scoring of each main and sub-attribute.
ii. Whether they agreed with the nomenclature of each main and sub-attribute.
iii. Their opinion about the definitions of each main and sub-attribute.
iv. The appropriateness of each sub-attribute to measure the skills necessary under its main attribute.
v. How would users of the rubric understand the criteria
vi. What should be rephrased, removed, added or what alternative nomenclature and descriptors may be more relevant or appropriate.
vii. Any further comments about the rubric overall, including recommendations for improvement.

The research team collated the quantitative and qualitative data into a table organized according to the rubric items. The aim was to revise the rubric and strengthen the validity of the subsequent rubric versions. These recommendations were then considered to create Version 3.0 of the KhAIR rubric. This new version was then sent to the subject matter experts again for Round 2 of content validation (Post-discussion Validation). The two rounds of expert validation were conducted between November 2022 and January 2023 to reach the required consensus level. The sections below describe the process for quantitative analysis first, and then the qualitative analysis is presented. Six subject matter experts participated in the KhAIR rubric content validity. Two rounds of content validations were necessary to achieve suitable validity levels.

Quantitative Analysis

The content validity analysis was conducted using SPSS v21 applying the Polit and Beck methodology (Polit, Beck & Owen, 2007). The quantitative analysis involved two main aspects:

i. Content validity of each main and sub-attribute.

The 'relevance' and 'clarity' of each sub-attribute were assessed by analysing the Item Content Validity Index ($I\text{-}CVI_{Relevance}$ and $I\text{-}CVI_{Clarity}$). Each sub-attribute $I\text{-}CVI_{Relevance}$ and $I\text{-}CVI_{Clarity}$ were calculated by dividing the number of experts rated as 'very relevant' (rating 4) or 'very clear' (rating 3), respectively, by the total number of experts. In addition, the overall Scale Content Validity Index for the 'relevance' ($S\text{-}CVI_{Relevance}$/Ave) and 'clarity' ($S\text{-}CVI_{Clarity}$/Ave) were also calculated as the average I-CVI of each main attribute. I-CVI and S-CVI values of 0.83 and above were accepted, and the main and sub-attributes were retained.

To assess the experts' agreement of a sub-attribute as 'essential' or 'necessary', the Content Validity Ratio (CVR) was calculated using this mathematical formula: $CVR = (2ne / N) – 1$ where CVR = content validity ratio, ne = number of experts indicating 'essential' (rating 3), and N = total number of experts. A negative CVR is when

less than half of the experts consider it essential, zero if half agree, one if all experts agree, and between zero and 0.99 if more than half but not all experts consider it essential (based on six experts). The main and sub-attributes with CVR values of 0.99 to 1 were considered acceptable.

ii. Content validity of the individual performance level.

The 'clarity' of each 'Performance Level' descriptor (i.e. 1-Beginning, 2-Developing, 3-Sufficient, 4-Proficient, 5-Exemplary) was analysed for each main and sub-attribute using I-$CVI_{Clarity}$ and S-$CVI_{Clarity}$/Ave as described above. Only the overall S-$CVI_{Clarity}$/Ave of 'Performance Level' was reported in this paper.

Qualitative Analysis

A cognitive interview approach was performed on the six subject matter experts who provided nuanced insights and practical perspectives on the rubric's applicability, comprehensiveness, and relevance to their personal assessment practices through structured consultations and collaborative discussions (Balza et al., 2022). By fostering this direct engagement, the research team gained a deeper understanding of the experts' perspectives, enabling more targeted adjustments to the rubric. The research team employed an iterative prototyping approach, developing successive drafts of the rubric based on the feedback received. The same subject matter experts were invited to review and provide input on each iteration, allowing for incremental improvements guided by their insights (Round 2). This iterative process ensured that the rubric evolved and improved in response to the expert feedback.

RESULTS & DISCUSSION

Development of the KhAIR rubric version 2.0 (Phase 1)

Table 2 presents the changes in the main and sub-attributes between Version 1.0 and Version 2.0 of the KhAIR rubric. The initial version comprised eleven sub-attributes. Following a thorough literature review (Steven & Levi, 2023 & Kapborg & Bertero, 2002) and discussions with the research team, this number increased to fourteen in the second version. The new sub-attributes were added to the *Amānah*, *Iqra'*, and *Rahmatan Lil' Alamin*, refining the initial sub-attributes.

For example, 'Work ethics' under *Amānah* was replaced by 'Competency' and 'Commitment & Dedication', which enhanced clarity and specificity by capturing distinct and crucial aspects of what was previously encompassed by 'Work ethics'. 'Competency' is a fundamental aspect of work ethics, as it emphasizes the importance of having the necessary skills and knowledge to perform tasks effectively. 'Commitment & Dedication' reflects an individual's devotion, perseverance and willingness to make the necessary effort and remain engaged with their tasks over time.

Another amendment in the KhAIR rubric Version 2.0 was 'Information management' under *Iqra'*, that was split into 'Sharing information' and 'Life-long learning'. According to Khamzah et al. (2017), information or knowledge management comprises three components: developing, storing, and sharing knowledge. Knowledge development is based on acquiring information or evidence from various sources that can be used or applied to formulate a solution during problem-solving endeavours. This approach emphasizes the importance of not merely hoarding knowledge but actively sharing it with others, fostering a lifelong learning culture (Khamzah et al., 2017).

Table 2: List of main and sub-attributes of the KHAIR Rubric Version 1.0 and 2.0

Main attributes	***Khalifah***		***Amanah***		***Iqra'***		***Rahmatan Lil 'Alamin***	
Version	**Version 1.0**	**Version 2.0**	**Version 1.0**	**Version 2.0**	**Version 1.0**	**Version 2.0**	**Version 1.0**	**Version 2.0**
Sub-attributes	Leadership Managing Skills Teamwork Communication Skills	Leadership Managing Skills Teamwork Communication Skills	Work ethics Integrity & Responsibility	Competency Commitment & Dedication Work Integrity & Responsibility	Problem Solving Profession Specific Skills Information Management	Problem Solving Evidence-Seeking Sharing-Information Life-long Learning	Community Engagement Sustainable Approaches	Social Sustainability Economic Sustainability Environmental Sustainability

Content Validation of the KhAIR rubric version 2.0 (Phase 2)

Based on the subject matter expert scores, the I-CVI, S-CVI and CVR for all four main attributes in the KhAIR and their sub-attributes were calculated and shown in Table 3. Results showed that the I-CVI values of the sub-attributes of *Khalīfah* and *Rahmatan lil - Alamin* (I-CVI: 0.8) were slightly below the expected cut-off value of 0.83. However, the S-CVI/Ave for the overall rubric showed acceptable values (S-CVI/Ave > 0.9).

The CVR calculations showed that four out of the 14 proposed sub-attributes (i.e., Leadership qualities, Managing skills, Teamwork, and Communication) did not achieve the cut-off value of 0.99 (CVR: 0.6). Similarly, the overall 'Performance Level' rating scale was very low (S-$CVI_{Performance\_level}$/Ave: 0.5) compared to the acceptable value. These findings suggested the need to revise the Version 2.0 of the KhAIR rubric, specifically the main and sub-attributes with low values of relevancy, clarity and essentiality

Table 3: Content validation for the first-round content validation by six subject matter experts (KhAIR rubric version 2.0)

Attributes	Sub-attributes	Relevance		Clarity		Essential	
		S-CVI / Ave	I-CVI	S-CVI / Ave	I-CVI	CVR /Ave	CVR
Khalīfah	Leadership qualities	0.95	1	0.8	0.8	0.6	0.6
	Managing Skills		1		0.8		0.6
	Teamwork		1		0.8		0.6
	Communication skills		0.8		0.8		0.6
Amānah	Competency	1	1	1	1	1	1
	Commitment and dedication		1		1		1
	Work integrity and responsibility		1		1		1
Iqra'	Problem solving	1	1	1	1	1	1
	Evidence seeking		1		1		1
	Sharing information		1		1		1
Raḥmatan lil-ʿālamīn	Lifelong learning	1	1	0.8	1	1	1
	Social responsibility		1		0.8		1
	Economic responsibility		1		0.8		1
	Environmental responsibility		1		0.8		1
Total KhAIR		0.99		0.90		0.90	

Ave: Average; CVR: Content Validity Ratio; I-CVI: Item-level Content Validity Index; S-CVI: Scale-level Content Validity Index

Development of the KhAIR rubric version 3.0 (Phase 2)

Based on the findings of Round 1 content validation, the expert's qualitative input from the group discussion indicated that further consideration should be given to expanding, revising, and clarifying the sub-attributes of each main attribute to provide a more comprehensive and rigorous assessment tool. For example, 'Leadership qualities', under the *Khalīfah* attribute, was perceived to be too broad a term and perceived more as a main attribute rather than a sub-attribute (Table 4). Upon deliberation, the research team agreed to replace 'Leadership qualities' with 'Inner stewardship' to better reflect the qualities of self-confidence, self-awareness, self-regulation, and self-efficacy to increase an individual's work performance and enable one to lead others at the organizational level (Golsby et al., 2021; Harari et al., 2021; Stewart, Courtright & Manz, 2018). The definitions of the other sub-attributes were rephrased to improve their clarity.

Other than introducing a new nomenclature, one sub-attribute was also added to the main attributes *Amānah* and *Rahmatan lil' alamin*, following an expert's suggestion that maintaining an equal number of criterions for each construct in a rubric promoted fairness, comprehensiveness, clarity, and ease of use in the assessment process, contributing to the validity and reliability of the evaluation outcomes. This increased the total number of sub-attributes from 14 in the KhAIR rubric Version 2.0 to 16 in the KhAIR rubric Version 3.0. The addition of the new sub-attributes was performed in two ways. Firstly, the perceived double-barrelled sub-attribute 'Work Integrity & Responsibility' under the attribute of *Amānah,* was separated to yield 'Work Integrity" and 'Responsibility". 'Responsibility' emphasizes the importance of individuals performing according to the job scopes/terms of references, and the job must be performed in an accountable and ethical manner (i.e. Integrity) (McGrath & Whitty., 2018; Bivins 2006; Vest et al., 2023). According to Said Nursi, as cited by Muslim, these two sub-attributes are developed within an individual based on the firm belief in Allah and the life of the hereafter (Muslim, 2016). Second, a new sub-attribute of 'Spiritual values' was added to the *Rahmatan lil' alamin* following the feedback of one of the subject matter

experts who emphasized its essential role in ensuring the success of the social, economic and environmental sustainability initiatives. This opinion was consistent with other researchers (Bensaid, 2018; Berejnoi, Messer & Cloutier 2020; Goralnik & Marcus, 2020; Dhiman 2024), suggesting spiritual values such as compassion, altruistic love, understanding, and empathy should be the driving force or motivation for an individual to engage in sustainable behaviours or *Rahmatan lil' alamin.*

Other than the sub-attributes, the nomenclature of each 'Performance Level' was further improved by changing from five levels to four levels with a new nomenclature: (1) Developing, (2) Approaching, (3) Meeting, and (4) Exceeding. The performance level descriptors were rephrased to accurately represent the expectations and achievements of the learning outcomes at each level. Changing to the 4-level or even number rating scale requires the users of this rubric to be more deliberate and precise in making definitive evaluations about the student's attainment of the learning outcomes (Chyung et al., 2017; Garland 1991; Busch 1993). In addition, it allows users to award a maximum score of 4 (Exceeding) to students who have achieved beyond the expected learning outcomes. In contrast, the 5-level rating scale seems more 'appreciative' to those who have achieved beyond the learning outcome with a score of 4 (Proficient) or 5 (Exemplary).

Table 4: List of main and sub-attributes of the KHAIR Rubric Version 2.0 and 3.0

Main attributes	***Khalifah***		***Amanah***		***Iqra'***		***Rahmatan Lil 'Alamin***	
Version	**Version 2.0**	**Version 3.0**	**Version 2.0**	**Version 3.0**	**Version 2.0**	**Version 3.0**	**Version 2.0**	**Version 3.0**
Sub-attributes	Leadership Managing Skills Teamwork Communication Skills	Inner Stewardship Managing Skills Teamwork Communication Skills	Competency Commitment & Dedication Work Integrity & Responsibility	Competency Commitment Integrity Responsibility	Problem Solving Evidence-Seeking Sharing-Information Life-long Learning	Problem Solving Evidence-Seeking Sharing-Information Life-long Learning	Social Sustainability Economic Sustainability Environmental Sustainability	Spiritual Values Social Sustainability Economic Sustainability Environmental Sustainability

Content Validation of the KhAIR rubric Version 3.0

Table 5 shows that the I-CVI values of the 16 sub-attributes of the KhAIR Rubric Version 3.0 exceeded the cut-off value of 0.83 (0.8 - 1). Overall, the calculations also revealed an improvement in the S-CVI values from 0.90-0.99 (Version 2.0) to 0.98-1.00 (Version 3.0). The CVR calculations for the revised *Khalīfah* sub-attributes also showed an improvement from 0.6 (Version 2.0) to 1.0 (Version 3.0). Similarly, the overall 'Performance Level' rating scale was improved from the S-CVI$_{Performance_level}$/Ave value of 0.5 (Version 2.0) to 0.98 (Version 3.0).

Table 5: Content validation for the second-round content validation by six subject matter experts (KhAIR rubric version 2.0)

Attributes	**Sub-attributes**	**Relevance**		**Clarity**		**Essential**	
		S-CVI / Ave	**I-CVI**	**S-CVI / Ave**	**I-CVI**	**CVR / Ave**	**CVR**
Khalīfah	Inner stewardship	1	1	1	1	1	1
	Managing Skills		1		1		1
	Teamwork		1		1		1
	Communication skills		1		1		1
Amānah	Competency	1	1	0.95	1	1	1
	Commitment		1		1		1
	Work integrity		1		1		1
	Responsibility		1		0.8		1
Iqra' bismirabbikalazi khalaq'	Problem solving	1	1	0.95	0.8	1	1
	Evidence seeking		1		1		1
	Sharing information		1		1		1
	Lifelong learning		1		1		1
Raḥmatan lil-ʿālamīn	Spiritual values	1		1	1	1	
	Social responsibility		1		1		1
	Economic responsibility		1		1		1
	Environmental responsibility		1		1		1
Total KhAIR		1		0.98		1	

Ave: Average; CVR: Content Validity Ratio; I-CVI: Item-level Content Validity Index; S-CVI: Scale-level Content Validity Index

To summarize, the expert evaluation confirmed that the rubric effectively covers and represents the essential non-cognitive skills and attributes outlined in the educational frameworks (MOE, 2013 & MOE 2019) and the iCGPA: Learning Outcome Assessment Guide Rubric (MOHE, 2016) and the quantitative analysis guided the refinement of the terminology and definition used in the rubric. The high total I-CVI and I-CVR ratings in the final quantitative analysis supports the conclusion that the KhAIR rubric effectively represents the intended educational goals when used as a whole rubric.

CONCLUSION

The KhAIR rubric was successfully developed using the combination of qualitative expert judgment and quantitative content validity analysis. High content validity was achieved, suggesting that all relevant content areas were accurately and comprehensively represented. Nevertheless, further research is needed to explore the reliability of the rubric and applicability across diverse health programmes and assessment types through a pilot study. Additionally, further investigation of its long-term impact on educational outcomes (e.g. student performance, professional competency) and practical implementation (e.g. integration into existing assessment practices, potential barriers) needs to be carried out. This study contributes to educational assessment literature by providing a robust framework for assessing healthcare student's attributes, emphasizing the development of value-based and holistic competencies.

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ORIGINAL ARTICLE

Prevalence of Flexible Flat Feet and its Association with Body Mass Index Among Young Adults of Malaysian University: A Preliminary Cross-Sectional Study

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ABSTRACT

Background: Flexible flat feet (FFF) are common yet often overlooked, especially among young adults. While excess body weight has been suggested as a contributing factor but the relationship between body mass index (BMI) and FFF remains unclear due to conflicting evidence. This study aimed to determine the prevalence of flexible flat feet and examine its association with BMI among young adults. **Methods:** A cross-sectional study was conducted among 190 university students aged 19–26 years. Flexible flat feet were assessed using the Navicular Drop Test and Jack's Toe-Raising Test. BMI was calculated based on measured height and weight and categorized into four groups. The prevalence of FFF was reported in frequency and percentages, while associations with BMI were analysed using the Chi-square test of independence, with Fisher's Exact Test applied when Chi-square assumptions were not met. Cramér's V was used to assess the effect size. **Results:** Flexible flat feet were identified in 26.3% (n = 50) of participants, with 20.0% having FFF on the left side, 18.4% on the right side, and 12.1% bilaterally. No significant associations were found between BMI and FFF: right foot (Fisher's Exact Test, p = 0.222; Cramér's V = 0.152), left foot (Fisher's Exact Test, p = 0.093; Cramér's V = 0.180), and bilateral (Fisher's Exact Test, p = 0.758; Cramér's V = 0.091). Effect sizes were small in all cases. **Conclusion:** Flexible flat feet affected nearly one-fifth of the study population. No significant association was found between BMI and FFF, suggesting that BMI alone may not be a reliable indicator of foot posture in young adults. These findings support the need for broader investigations incorporating other biomechanical and lifestyle factors.

INTRODUCTION

The human foot complex, an essential unit of lower limb has a very complex anatomical structure that assists in weight bearing by countering the rotational forces applied by proximal joints of lower limb. Its flexible structure provides a shock absorption feature which enables the plantar region to accommodate force on different surfaces during locomotion. Other than that, the foot has a substantial role in postural control and balance during standing (Viseux, 2020). Considering these essential functions, any structural or nonstructural pathology on the foot can be disabling and affect the quality of life. One such pathology is flat foot or pes planus, which is defined as the loss of medial longitudinal arch of the foot, heel valgus deformity and medial talar prominence (Troiano et al., 2017). Flat foot is classified based on various criteria and one of it is whether the flat foot structure is rigid or flexible. Flexible flat foot(FFF) is the commonest type in which the medial longitudinal arch appears to be normal in a non-weight bearing position but the arch drops excessively on standing (Neumann et al., 2017). Whereas in rigid flatfoot, the medial longitudinal arch is flattened in both weight bearing and non-weight bearing positions (Halabchi et al., 2013). Studies have reported the prevalence of flexible flat feet to be significant among young adults. Research indicates a prevalence rate of 20% among individuals aged 18–25 years (Abaraogu et al., 2016) while another study found it to be 13.6% in adults aged 18–21 years (Aenumulapalli et al., 2017). Whereas some studies have reported the prevalence of flexible flat foot as high as 78 percent (Nakhanakhup & Ingkatecha, 2014).

Despite its high prevalence, flexible flat feet often go unnoticed due to their asymptomatic nature. However, they can impact lower limb joints in a distal-to-proximal sequence, affecting the foot, knee, hip, and lumbar spine as part of a dynamic kinetic chain (Anvita Telang & Supriya Dhumale, 2020). Studies show that foot pronation induces medial rotational torque in the tibia, leading to internal rotation in the femur, which affects pelvic alignment and spinal posture(Khamis et al., 2015; Rockar, 1995) . A strong correlation was found between flat feet condition and core muscle endurance, with individuals having flexible flat feet, exhibiting reduced core muscle endurance (Elataar et al., 2020; V & Roshan, 2021). The association between flat feet and reduced core muscle endurance highlights the

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importance of identifying and managing this condition early, as untreated flatfoot can lead to further musculoskeletal issues.Hence need for increased awareness and attention to potential consequences related to flat feet should be addressed in general population.

The cause of flat feet remains a topic of ongoing debate among researchers, with various factors proposed. Some studies highlight the role of improper footwear as an important contributing factor (Bhaskara Rao & Joseph, 1992; Joseph, 1995). Some authors point to obesity or elevated body mass index (BMI) as one of the causes of flat feet among adults as well as among children, due to the excessive pressure exerted by increased body weight on the medial longitudinal arch (Senadheera, 2016; Vijayakumar et al., 2016). The strong association claimed by the studies makes this population susceptible to lumbar spine disorders in future due to the altered biomechanics caused by foot pronation and arch collapse, which can affect alignment throughout the kinetic chain, including the pelvis and spine (Anvita Telang & Supriya Dhumale, 2020; Khamis et al., 2015). Although several studies have reported a significant association between BMI and flat feet, findings remain inconsistent, with some reporting no relationship at all (Atamtürk, 2009; Carvalho et al., 2017).

To our knowledge there is currently no data on prevalence of flexible flat feet and its link to BMI within Malaysia, where racial and ethnic variations may influence both BMI distribution and foot structure, potentially affecting the relationship between the two. Given these inconsistencies in literature and the lack of data within the Malaysian context, this study serves as a preliminary cross-sectional investigation to estimate the prevalence of FFF and to investigate its relationship with BMI among Malaysian young adults.

MATERIALS AND METHODS

Study design

The study was conducted at a local university Campus, chosen for its convenient location and accessibility to participants. A cross-sectional design was used to estimate the prevalence and examine the association between flexible flat feet and body mass index (BMI) in male and female students who met the inclusion and exclusion criteria.

Participants

A non-probability convenience sampling method was used, selecting easily accessible participants. Information was shared via a poster and viral message across WhatsApp groups, inviting voluntary participation. Informed consent was obtained from all participants.

The sample size was calculated using the single proportion formula to estimate prevalence of flexible flat feet in the study population. Based on an expected prevalence of 13.6% with a 95% confidence interval, 5% precision (Aenumulapalli et al., 2017), and accounting for a 5% non-response rate, the required sample size was approximately 190 participants.

While the sample size was primarily calculated to estimate prevalence, it was also used to explore the association between BMI and flexible flat feet. Based on Vijayakumar et al. (2016), who reported a strong relationship between BMI and flat feet in a sample of 412 adults, we conservatively estimated a large effect size (Cramr's V = 0.30). Using this value for power analysis ($\alpha = 0.05$, power = 0.80, df = 3), the minimum required sample size would be approximately 88 participants. Since our study included 190 participants, the sample size was more than adequate to detect an association of this magnitude.

Participants aged 19-26 years, enrolled at International Islamic university of Malaysia(IIUM), Kuantan Campus, with no prior history of ankle and foot injuries, without any history of back pain were included. Exclusions included individuals with foot pain, injury, surgery, neurological issues, congenital deformities, or those using orthopaedic foot devices. University students were chosen due to their accessibility and their representation of the young adult age group (18–26 years), which is commonly studied in flexible flat foot research due to its higher prevalence and relevance for early screening (Abaraogu et al., 2016; Aenumulapalli et al., 2017).

Data collection

Interested participants, who responded to recruitment messages shared via student WhatsApp groups, were invited to the assessment area, where their eligibility was screened prior to participation. Data collection was carried out over a period of three months, from October to December 2024. Those meeting the criteria received a detailed study explanation, and informed consent was obtained. Data collection consisted of three parts: demographic data, BMI measurements, and foot assessment. A single assessor conducted all examinations. This assessor was trained and supervised by a qualified physiotherapist prior to the start of data collection to ensure consistency and accuracy.

Basic demographic information of participants was recorded; weight and height were measured. The weight of participants was measured using a calibrated weighing machine (Aesthesiometer). Participants were instructed to remove heavy clothing, shoes, and accessories before stepping onto the weighing scale. They were asked to stand upright and still, ensuring their weight was evenly distributed on both feet. The weight was recorded to the nearest 0.1 kg. Height was measured using a stadiometer. Participants were asked to remove their shoes and any headwear that could interfere with accurate measurement. They stood upright with their heels together, ensuring their back, shoulders, and head were in contact with the stadiometer's vertical surface. The head was positioned such that the Frankfurt plane (a horizontal line from the ear canal to the lower edge of the eye socket) was parallel to the floor. The movable headpiece was gently lowered until it touched the crown of the participant's head without pressing. Height was recorded to the nearest 0.1 cm (Pourghasem et al., 2016). Body Mass Index (BMI) was calculated by dividing body weight (kg) by the square of height (m^2). The following classification of BMI was followed: BMI below 18.5 indicates underweight, a BMI between 18.5 and 24.9 is considered normal weight, a BMI between 25 and 29.9 is categorized as overweight, and a BMI of 30 or greater is classified as obese [19] (Pourghasem et al., 2016).

The foot assessment was conducted using two tests: the Navicular Drop Test (NDT) and the Jack's Toe Raising Test(JTRT). Participants were considered to have flexible flat feet only if they tested positive on both assessments.

The NDT assesses the degree of foot pronation by measuring the displacement of the navicular bone between the subtalar joint's neutral position and relaxed standing. Participants were seated on a chair with their feet flat on the floor. The examiner palpated the medial longitudinal arch to locate the navicular tuberosity, and a dot was marked at the most prominent part of the navicular tuberosity. A card was placed vertically against the medial side of the foot, and the height of the marked navicular tuberosity from the floor was measured in the subtalar neutral position. Then participants were asked to stand in a relaxed position, and the height of the navicular tuberosity from the floor was measured again. The difference in height between the two positions (neutral and relaxed standing) was recorded as the navicular drop. A drop greater than 10 mm was considered positive for excessive pronation (D M Brody, 1982). The Navicular Drop test has demonstrated an excellent intrarater and interrater reliability (>0.880) and significant corelations with arch angle (0.643), Staheli index (0.633) and Chippaux-Smirak index (0.614) in the assessment of flat feet(Zuil-Escobar et al., 2018).

To ensure flat feet were of flexible in nature and avoid likelihood of misclassification, Jack's Toe Raising test was used as a secondary assessment tool. Flexibility of the medial longitudinal arch is tested by observing arch formation upon dorsiflexion of great toe. Participants stood barefoot, with equal weight on both feet. The examiner gently dorsiflexed the participant's big toe (hallux) to approximately 30° while observing the medial longitudinal arch. A positive test was noted if the medial longitudinal arch reformed or lifted during the dorsiflexion maneuver, indicating flexibility. If the arch remained collapsed, the test was considered negative. This test has been reported to effectively detect flexible flat feet, making it a reliable and essential component in distinguishing between flexible and rigid flat foot deformities (Mosca, 2010). Furthermore, the test has demonstrated strong psychometric properties. Studies have reported excellent reliability, with intraclass correlation coefficients (ICCs) ranging from 0.928 to 0.999, as well as perfect sensitivity and specificity, supporting its validity as a clinical tool for diagnosing functional hallux limitus related to foot posture (Sánchez-Gómez et al., 2020).

Participants were classified as having flexible flat feet only if they tested positive on both the Navicular Drop Test (drop >10 mm) and Jack's Toe Raising Test (arch reformation upon dorsiflexion).

Investigating researchers conducted three practice trials for BMI measurement and foot assessment procedures prior to the start of the study. This was done to ensure familiarity with the methods, enhance procedural consistency, and minimize errors during the actual data collection process.

Statistical analysis

The data was analyzed using the Statistical Package for Social Science (SPSS), version 20 for Windows. Demographic data, including participants' age, were summarized using means and standard deviations. Age groups (19, 20, 21, 22, 23, 24, and 25 years) and gender distribution were analyzed and presented as frequencies and percentages. BMI was summarized as means and standard deviations for males, females, and the total sample. Participants were further categorized into four BMI groups (underweight, normal, overweight, and obese), with frequencies and percentages reported for each gender. The presence of flat feet among the 190 participants was reported as frequencies and percentages.

The association between flexible flat feet (right, left, and bilateral) and BMI categories was initially analyzed using the Chi-Square Test of Independence. Assumptions of the Chi-square test were checked, and when more than 20% of cells had expected frequencies less than 5 (particularly in cases like bilateral flat feet), Fisher's Exact Test was used to ensure valid statistical interpretation. A p-value of <0.05 was considered statistically significant. For each association, effect size was assessed using Cramer's V to evaluate the strength of association. According to commonly used guidelines, Cramér's V values of 0.1, 0.3, and 0.5 indicate small, medium, and large effect sizes, respectively.

RESULTS

Demographic data

A total of 190 undergraduate students participated, with a mean age of 21.28 ± 1.32 years. Most participants were female (n = 127, 66.8%), while males comprised 33.2% (n = 63). Table 1, provides the detailed demographic characteristics, including age distribution.

Body Mass Index (BMI)

Table 2 presents the BMI categories, summarized by frequencies and percentages. The mean BMI of participants was 23.52 ± 4.81 kg/m², with males at 23.86 ± 3.87 kg/m² and females at 23.35 ± 5.22 kg/m². Most participants (56.8%) were in the normal BMI category, followed by overweight (20.6%), obese (11.5%), and underweight (11.1%).

Prevalence of Flexible flat feet by side and gender

Among the participants, 26.3%(n=50) tested positive for FFF. 20.0% (n = 38) tested positive for FFF on the left side, and 18.4% (n = 35) on the right side. Bilateral FFF were observed in 12.1% (n = 23) of the participants. Table 3 summarizes the frequency and percentage of participants found positive for flexible flat feet by side and gender.

Association between flat feet and BMI

The relationship between flexible flat feet (right, left, and bilateral) and BMI was analyzed using Fisher's Exact Test, as the assumption for the Chi-square test was violated (≥25% of expected cell counts were less than 5). The analysis revealed no statistically significant association between BMI and any type of flexible flat feet. For the right foot, the association was not significant (Fisher's Exact Test, p = 0.222; Cramer's V = 0.152), indicating a small effect size. Similarly, the left foot also showed no significant association (Fisher's Exact Test, p = 0.093; Cramer's V = 0.180), suggesting a small effect size. For bilateral flexible flat feet, the result remained non-significant (Fisher's Exact Test, p = 0.758; Cramer's V = 0.091), with a very small effect size. The results of association between FFF and BMI are summarised in Table 4. These findings suggest that BMI may not be a key factor influencing the presence of flexible flat feet, and other biomechanical or environmental variables may play a more substantial role.

Table 1: Demographic Characteristics of Participants

Variables	**Frequency**	**Percentage (%)**
Age (mean ± SD = 21.28 ± 1.32)		
19	26	13.7
20	30	15.8
21	22	11.6
22	98	51.6
23	9	4.7
24	2	1.1
25	2	1.1
26	1	0.5
Total	190	100.0
Gender	**Frequency**	**Percentage (%)**
Male	63	33.2
Female	127	66.8
Total	190	100.0

Table 2: Distribution of Body Mass Index (BMI) categories among Participants

Variables		**Males (n=63)**	**Females (n=127)**	**Total (n=190)**
BMI, mean ± SD (kg/m²)		23.86± 3.87	23.3± 5.22	23.52 ±4.81
Category of BMI, n(%), (kg/m²)	Underweight	3 (1.6)	18 (9.5)	21 (11.1)
	Normal	34 (17.9)	74 (38.9)	108 (56.8)
	Overweight	21 (11.1)	18 (9.5)	39 (20.6)
	Obese	5 (2.6)	17 (8.9)	22 (11.5)

SD-Standard deviation, BMI-Body mass index

Table 3: Frequency and percentage of flexible flat feet by side and Gender

Side	**Interpretation of foot assessment**	**Male (n=63)**	**Female (n=127)**	**Total (n=190)**
FFF Left Side, n(%)	Positive	14 (22.2)	24 (18.9)	38 (20.0)
	Negative	49 (77.8)	103 (81.1)	152 (80.0)
FFF Right Side, n(%)	Positive	10 (15.9)	25 (19.7)	35 (18.4)
	Negative	53 (84.1)	102 (80.3)	155 (81.6)
Bilateral FFF, n(%)		6 (3.2)	17 (8.9)	23 (12.1)
Overall FFF*(any side), n(%)	Positive	18(28.6)	32(25.2)	50(26.3)
	Negative	45(71.4)	94(74.0)	139 (73.2)

FFF- Flexible flat feet

[*]Overall FFF (any side) represents participants who tested positive for flat feet on either foot or both feet (i.e., counted once per individual)

Side	N (valid cases)	χ^2 (df)	Fisher's Exact p	Cramer's V	Interpretation
Right FFF	190	4.364[*] (3)	0.222	0.152	No significant association; weak effect size
Left FFF	190	6.152[*] (3)	0.093	0.180	No significant association; weak effect size
Bilateral FFF	190	1.561[**] (3)	0.758	0.091	No significant association; weak effect size

Table 4: Association Between Flexible Flat Feet (Right, Left, and Bilateral) and Body Mass Index (BMI)
FFF- Flexible flat feet
χ^2 (df)-Chi-square statistic with degrees of freedom
[*]2 cells (25%) have expected counts <5
[**]3 cells (37.5%) have expected counts <5

DISCUSSION

This study investigated both the prevalence of flexible flat feet and its association with body mass index (BMI) among university students. Flexible flat feet were identified in 26.3% of participants. 20.0% tested positive on the left side, 18.4% on the right side, and 12.1% bilaterally.

The observed prevalence in this study aligns with several previous investigations in similar age groups. Abaraogu et al. (2016) reported a prevalence of 20% among adults aged 18–25 years, while Aenumulapalli et al. (2017) found a slightly lower prevalence of 13.6% in the 18–21 age group. However, Nakhanakhup and Ingkatecha (2014) reported a substantially higher prevalence of 78%, which may reflect differences in methodology, population characteristics, or assessment criteria. These variations highlight the importance of standardizing assessment tools and considering demographic influences when interpreting prevalence data

No significant associations were found for any condition: right flexible flat feet ($p = 0.222$), left flexible flat feet ($p = 0.093$), and bilateral flexible flat feet ($p = 0.758$). These findings suggest that BMI may not significantly influence foot structure in this population. Other factors, such as genetics, physical activity, and footwear habits, may play a larger role. This study adds to the limited literature on this relationship in young adults, compared to pediatric and older adult populations.

The absence of a significant association between BMI and flexible flat feet may be attributed to the multifactorial nature of foot posture, which is influenced by various factors beyond body weight. Young adults typically have more stable foot structures, and the BMI range in this group may not have been extreme enough to impact arch mechanics. Therefore, BMI alone may not serve as a reliable indicator for flat foot posture in this demographic.

Previous studies investigating the relationship between BMI and flexible flat feet have yielded mixed results, in both pediatric populations and adult populations. For instance, a study on subjects aged 2 to 14 years found that excess weight influenced foot morphology, with flat feet being more prevalent among overweight children (Mauch et al., 2008). Similarly, another researcher reported an altered foot growth pattern in overweight children aged 6 to 12 years compared to those with normal weight (Jiménez-Ormeño et al., 2013).

In contrast, some studies have reported no significant association between BMI and foot posture among adolescents aged 10 to 14 years(Carvalho et al., 2017). Similar findings were reported in younger age groups, including children aged 3 to 15 years and 7 to 10 years, where no relationship was observed between BMI and foot posture (Evans, 2011; Evans & Karimi, 2015).

A notable observation across these studies is that those reporting a positive relationship between BMI and flat feet predominantly included participants below 10 years of age, whereas studies reporting no association tend to focus on older children and adolescents. This age-related trend is intriguing and suggests that age might play a moderating role in the relationship between BMI and foot posture. Evidence from previous studies supports the notion that foot posture undergoes significant changes during development. For instance, younger children are more likely to exhibit pronated feet due to the ongoing

development of the longitudinal arch, and a U-shaped relationship between age and foot posture has been described (Staheli, 1987). These findings suggest the influence of age-related changes on foot structure, although the precise mechanisms remain unclear and warrant further investigation.

While insights from studies on children and adolescents provide valuable context for understanding how BMI may influence foot structure during growth and development, these findings cannot be directly extrapolated to adults. Unlike children, whose feet are still developing and adapting to weight-bearing demands, adults have fully matured foot structures that are less susceptible to the biomechanical changes associated with growth. Given these distinctions, the present study aimed to explore the relationship between BMI and foot posture in adults, addressing gaps in the literature and clarifying how body weight affects foot mechanics.

As discussed earlier, the presents study did not find any significant association between BMI and flat feet among adults aged between 19-26 years. These findings align with previous research conducted in adult populations and reported no association between presence of flat foot or high arched foot and BMI in community individuals aged 18 to 83 years (Atamtürk, 2009). Additionally, the study observed a decline in the prevalence of both flat feet and high-arched feet with increasing age. Similarly, a study focusing on 18–23-year-old medical students, a demographic comparable to the present study, also found no significant association between obesity and flat feet (Ramos et al., 2021).

Interestingly, some studies have highlighted age-dependent variations in the relationship between BMI and flat feet. For instance, a study reported significant correlation between BMI and flat feet in 12–15-year-olds, but this correlation disappeared in older adolescents aged 16–17 years (Daneshmandi et al., 2009). Likewise, another study on adolescents found no correlation between flat feet and variables like weight and height (Feridun Cilli, 2009).However, contrasting evidence exists. Some authors have reported a significant correlation between BMI and flat feet in adults aged 18–25 years (Chougala et al., 2015). Similar results were observed with significant association within the 18–22-year age group (Mallashetty et al., 2019).

These divergent findings highlight the complexity of the relationship between BMI and foot structure. When considering studies among adults, the majority report no significant relationship between BMI and flat feet. Supporting this observation, a meta-analysis comprising 1,648 participants with a mean age of 42.3 years (range: 3–96 years) found no evidence of a relationship between the Foot Posture Index (FPI) and BMI (Redmond et al., 2008).

A critical distinction noted by authors of present study is that many studies reporting positive associations used footprint-based methods to assess flat feet. This may have been influenced by the adiposity of the feet, as suggested by previous research indicating that increased BMI can affect arch index values, acting as a confounding factor in footprint assessments (Wearing et al., 2004). The effect of the fat pad on the plantar aspect of the foot in children and younger populations may contribute to the positive correlation between BMI and foot posture observed in studies using footprint methods. This hypothesis is further supported by research employing podoscopic examination, which revealed a statistical correlation between adiposity and the medial longitudinal arch (MLA) (Woźniacka et al., 2013). This suggests that the influence of body fat on foot structure may differ across age groups, particularly in children and adolescents, where foot development is ongoing. In contrast, the present study was conducted on adults aged 19 to 26 years, where the chances of fat pad are minimal. It employed the navicular drop test, a reliable indicator of flat feet, and Jack's toe raise test as an additional criterion. These tests are less likely to be influenced by body composition compared to footprint assessments, which could explain the discrepancies between the findings of the present study and studies reporting positive relationships.

The current study acknowledges the limitation, that it was conducted as a preliminary, single university campus cross-sectional investigation and employed non-probability convenience sampling and thus may not fully represent the general population of young adults in Malaysia. This approach was selected due to financial and time constraints. Also, the demographic composition (including ethnicity and academic background) of participants was not stratified. As such, location bias may limit the generalizability of findings to other regions or populations in Malaysia. Additionally, several potential confounding factors such as physical activity level, type of footwear, and lifestyle habits were not measured or controlled for. These variables could influence foot posture and may interact with BMI in complex ways.

Given the limitations of the current study and the interpretations drawn from both its findings and previous research, the ongoing inconsistencies in the literature highlight the need for larger, more methodologically robust studies to better understand the relationship between BMI and flat feet. Future research should aim to address these methodological limitations by employing

probability based sampling, including more diverse and representative populations, and considering potential confounding factors such as physical activity levels, footwear habits, and gender differences. Additionally, longitudinal designs may help clarify causality and provide deeper insight into how BMI may influence foot posture across different age groups and ethnic backgrounds.

CONCLUSION

This study examined the relationship between BMI and flexible flat feet in adults aged 19–26 years, finding no significant association. These results align with adult studies but contrast with research in children, possibly due to methodological differences and developmental factors.These findings suggest that BMI alone may not be a sufficient screening factor for flat feet among adults significantly influence adult foot structure, as as other biomechanical or lifestyle-related factors may play a more significant role influencing the foot structure. The use of non-probability convenience sampling limits generalizability, therefore future studies should use larger samples and confounding variables to clarify this relationship. These findings may guide clinicians to adopt a more comprehensive assessment approach when evaluating adult foot posture.

ETHICS

Ethical approval for this study was obtained from the IIUM Research Ethics Committee (IREC) (reference no.: IIUM/504/14/11/2/IREC 2024-KAHS/DPRS07; Date: November 22, 2024)

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ORIGINAL ARTICLE

Staffs Perceptions of Important Indicators and Self-Assessment of Hospital Food Service Operations Performance

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ABSTRACT

Background: Enhancing hospital food services performance can be challenging as identifying components that influence accurate evaluation is a critical element of organisational success.Thus, this study was conducted to assess staff perceptions of key performance indicators and their self-evaluation on the performance of hospital food service operations. **Methods:** This cross-sectional survey was conducted using a validated and reliable self-administered questionnaire. Respondents were selected from the food service staffs at Malaysian hospitals based on specific inclusion and exclusion criteria. The data analysis was performed using IBM SPSS version 26.0 software. The sociodemographic data was examined, and the means of importance and performance indicators were compared using a paired-sample t-test. The IPA grid was generated by integrating the means scores of importance and performance. **Results:** A total of 160 respondents comprising 35 males (21.9%) and 125 females (78.1%) completed this survey. The gap analysis reveals that eleven indicators demonstrate a significant difference between staff evaluation of hospital food service performance and their perceptions of the importance of food service attributes (p<0.01). Five indicators have been identified by the IPA grid that require improvement in the areas of food production and distribution management, as well as patient and customer service management. **Conclusions:** The findings suggest that hospital food service providers should focus on using a variety of food ingredients, evaluating their menus, and monitoring the health and cleanliness of their staff in order to improve their service quality.

INTRODUCTION

Performance improvement in food service organisations refers to the ongoing assessment and adaptation of the organisation's operations and procedures to increase the probability of accomplishing the desired outcomes and better satisfy the demands of customers (Payne-Palacio & Theis, 2016). A performance improvement disposition in food industry implies taking all the required steps to ensure high-quality food products and services, optimal service quality, increased satisfaction, and financial success (Gregoire, 2017). This approach aims to maximise quality and efficiency, improve overall performance, and provide benefit consumers (Payne-Palacio & Theis, 2016).

To assess quality and identify marketing-relevant performance aspects, Martilla and James (1977) developed a straightforward and useful tool known as the Importance-Performance Analysis (IPA). The IPA has been widely used to guide for quality improvement across diverse domains including healthcare, IT service, service quality, customer evaluation, marketing management, hospitality and tourism, banking, education, and transportation (Markazi-Moghaddam et al., 2019).

Moreover, previous research has demonstrated that IPAs are useful instruments for evaluating the importance and performance of food service quality attributes in various settings, including hospitals, childcare facilities, educational institutions, residential food services, and dining establishments (Abdelaty & Abdel Aal, 2017; Choi & Ju, 2022; Lee, 2016; Lee & Park, 2016; Park et al., 2017; Park & Lyu, 2011; Roy et al., 2020). Additionally, numerous studies have been conducted in South Korea adopting the IPA to determine alternatives that may improve quality in food service operations within healthcare settings (Lee, 2012, 2016; Lee & Park, 2016; Park & Lyu, 2011; Song & Bae, 2013).

Previous studies in Malaysia have employed the IPA approach to evaluate customer satisfaction and quality improvement in various sectors, including banking,

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healthcare, tourism, and business marketing (Dewi et al. 2013; Irwana et al., 2018; Islam & Madkouri, 2018). However, only one study used the IPA approach to evaluate how satisfied customers were with the food service in a university cafeteria (Akbara et al., 2021).

The quality of hospital meal service is generally assessed using patient satisfaction, food consumption, and food waste indicators (Dall'Oglio et al., 2015). However, understanding hospital food service management is also essential for enhancing food service operations (Vijayakumaran et al., 2018). The viewpoints and experiences of key stakeholders increase the understanding of hospital food procurement, production, and service about patient orders, which in turn influence patient satisfaction and food intake (Ahmed, 2018; Ahmed et al., 2015; Vijayakumaran et al., 2018).

Previous studies have shown that the overall satisfaction with food services can be predicted by the quality of the food, however, limited studies have indicated that the overall process involved in food service operations play an essential role in patient satisfaction with food quality (Ahmed, 2018; Ahmed et al., 2015). In this study, the IPA approach was proposed to address this gap by evaluating staff perceptions of important indicators and their self-assessment of the performance hospital food services, aiming to enhance overall hospital food service quality.

MATERIAL AND METHODS

Study design and data collection

This cross-sectional survey was carried out between November 2023 and January 2024. Prior to data collection, ethical approval was acquired from the Malaysian Ministry of Health, the Clinical Research Council, and the Research Management Institute at Universiti Teknologi MARA. The respondents were contacted by phone, email, and the WhatsApp app to obtain their consent for the collection of their data. Respondents were chosen based on the following criteria: they had to be Malaysian citizens; be employed in the food service and dietetics department's administrative team as a head of department, manager, dietitian or catering dietitian, catering or assistant catering officer; have at least six months of experience in the field; and be fluent in Malay and/or English. Individuals who did not meet the inclusion criteria were excluded from the study. The questionnaires were distributed via a Google Form URL link. Before completing the questionnaire, their informed verbal consent was obtained.

Sample size

The sample size for this study was determined using the formula provided by Bujang et al. (2012). The formula indicates that for response formats containing four or more items, it is advisable to have a minimum sample size of three respondents per item for conducting exploratory factor analysis. This study employed a five-point Likert scale, necessitating a minimum sample size of 1:3 for each item. Consequently, the minimum sample size necessary for a scale consisting of 17 items is 61 samples, accounting for a 20% dropout rate.

Survey instrument

A revised self-administered questionnaire developed by Osman et al. (2023) was utilised in this study. The questionnaire contained three sections: A) socio-demographic variables; B) the perception of importance indicators; and C) an evaluation of performance indicators. The sections B and C provided clear definitions of the "importance" and "performance" indicators to facilitate a better understanding prior to the respondents assigning their scores. All importance indicators were rated on a 5-point scale, with 1 indicating "very unimportant" and 5 indicating "extremely important". Another 5-point scale varied from 1 (far below standard) to 5 (far above standard).

Validity and reliability of the survey instrument

Prior to the distribution of the questionnaires, IBM SPSS Statistics version 26 for Windows was used to assess construct validity and internal consistency. For construct validity, the Exploratory Factor Analysis (EFA) with the principal component method of extraction and varimax rotation was used to estimate the number of factors and guide decisions on whether to retain or reject items. The statistical significance level for the p-value was set at less than 0.05. The repeated EFA indicated three factors: food production and distribution management, patient or customer service management, and operational management, which accounted for 69.9% of the total explained variation based on scree plot analysis and Eigenvalues greater than 1.0. The factor loading ranged from 0.575 to 0.893, and the commonalities between all revised items exceeded 0.50.

Cronbach's alpha and composite reliability (CR) were used to assess the internal consistency of the overall scale and subscales. Cronbach's alpha coefficient for factors with total scale reliability was 0.891. The Cronbach's alpha coefficient for the overall scale and factors was greater than 0.70, indicating that the items correlated with their

component groups, demonstrating internal consistency (Taber 2018). The composite reliability ratings for food production and distribution, patient or customer service, and operational management were 0.944, 0.879, and 0.845, respectively, indicating internal consistency among scale components. Composite reliability levels of 0.6 to 0.7 are considered acceptable (Shrestha, 2021).

Data analysis

The data for this study was analysed using IBM SPSS version 26.0. Socio-demographic data were analysed using descriptive statistics including frequency, percentage, and means. The means of importance and performance indicators were compared with a paired-sample *t*-test. The importance-performance matrix was generated by combining the mean importance and performance values for the hospital food service indicators. These values were then used to analyse each plot in the importance performance analysis grid (Martilla & James, 1977). The IPA grid along with its indications is presented in Figure 1.

Figure 1: The example of IPA grid

RESULTS

Socio-demographic characteristics

Table 1 shows that 35 (21.9%) of the 160 respondents to this survey were males, while 125 (78.1%) were females. The average age was 33.31 (±5.65), while the length of service was 7.53 (±5.66). The majority of them were catering officers/assistant catering (n=95, 59.4%), and 120 of them had a degree (n=120, 75.0%). Out of 160 respondents, 101 (63.1%) of them worked in government hospitals, 117 (73.1%) are from in-house food service operations, and 106 (66.3%) are from hospitals that employ centralised food delivery systems.

Table 1: Socio-demographic characteristics of the respondents. (N=160)

Characteristics	n (%)	Mean (*SD*)
Sex		
Male	35 (21.9)	
Female	125 (78.1)	
Age (years)		33.31 (5.65)
Length of service (years)		7.53 (5.66)
Job position		
Director/ Operation director/ Head of department	21 (13.1)	
Manager/ Catering manager/ Outlet manager	7 (4.4)	
Dietitian/ Catering dietitian	37 (23.1)	
Catering officer/ Assistant catering officer	95 (59.4)	
Academic qualification		
Diploma	37 (23.1)	
Degree	120 (75.0)	
Master/ PhD	3 (1.9)	
Type of hospital		
Government	101 (63.1)	
Private	46 (28.7)	
Teaching	13 (8.1)	
Type of food service operation		
In-house/self-operated	74 (46.3)	
Outsources/contracted	36 (22.5)	
Type of food delivery system		
Centralised	12 (7.5)	
Decentralised	28 (17.5)	
Hybrid	10 (6.3)	

Gap analysis of staff's perceptions of importance scores and evaluation of performance scores

Paired sample *t*-tests were used to determine the mean differences of staff perceptions between importance and performance indicators for hospital food service attributes are shown in Table 2. The mean and standard deviation for overall importance indicators were 2.83±0.06, while the mean and standard deviation for overall performance indicators were 2.91±0.07. The staff's perceptions of the importance of indicators and their overall performance indicators did not differ significantly (t (df) = -1.80 (159), p=0.073). The indicator "Utilisation of standardised recipe in the development of normal and therapeutic menus" scored the highest in performance (3.70±0.07), while "Utilisation of a variety of ingredients" had the greatest importance score (3.16±0.10). On the other hand, "Temperature control of raw materials and storage area" had the lowest performance rating (2.54±0.09) and "Existence of purchasing and ordering standards and procedures" received the lowest importance rating (2.47±0.09). The importance and performance scores for indicators 3, 5, 6, 7, 8, 10, 11, 12, 13, 14, and 17 differed significantly (p<0.01). It was discovered that the staff's

perception on the significance of these indicators outweighed their assessments of their performance.

Table 2: Gap analysis of staff's perception on the importance and performance scores for food service attributes. (N=160)

Indicators	Mean ± SD		Gap (I – P)	*t* (*df*)	*p*-value
	Importance (I)	Performance (P)			
Operational management					
1. Review the contract's specification/ standard of procedure (SOP) periodically.	2.69±0.09	2.84±0.10	-0.15	-1.12 (159)	0.267
2. Systematization of the diet ordering process.	2.48±0.09	2.79±0.10	-0.31	-2.38 (159)	0.180
3. Existence of purchasing and ordering standards and procedures.	2.47±0.09	2.89±0.10	-0.42	-3.07 (159)	0.003*
4. Inspection of all food ingredients at all points (e.g. receiving, storing, food preparation, etc.)	2.56±0.08	2.76±0.10	-0.20	-1.57 (159)	0.119
Food production and distribution management					
5. Utilisation of a variety of ingredients.	3.16±0.10	2.63±0.09	0.53	5.79 (159)	0.000**
6. Temperature control of raw materials and storage area.	2.79±0.10	2.54±0.09	0.25	2.83 (159)	0.005*
7. Kitchen staffs in neat and clean uniforms.	2.97±0.10	2.73±0.09	0.24	2.71 (159)	0.007*
8. Verify if any infectious diseases are present among the staffs.	3.03±0.11	2.81±0.10	0.22	2.72 (159)	0.007*
9. Nutritional analysis of menu.	2.87±0.10	2.88±0.09	-0.01	-0.08 (159)	0.939
10. Menu evaluation.	3.05±0.09	2.73±0.09	0.32	3.83 (159)	0.000**
11. Establishing standards for nutritional recommendations and menu planning.	2.76±0.10	3.54±0.08	-0.78	-5.93 (159)	0.000**
12. Utilisation of standardised recipe in the development of normal and therapeutic menus.	3.06±0.10	3.67±0.07	-0.61	-4.19 (159)	0.000**
13. Monitoring the cleanliness of food production and assembly areas.	2.79±0.09	3.03±0.10	-0.24	-2.69 (159)	0.008*
Patient or customer service management					
14. Overall patient/customer satisfaction.	2.71±0.10	3.05±0.10	-0.34	-2.60 (159)	0.010*
15. Overall food quality and taste.	2.73±0.09	2.94±0.10	-0.21	-1.54 (159)	0.125
16. Providing a variety of food choice for patient with normal diet.	2.88±0.11	2.97±0.10	-0.09	-0.74 (159)	0.459
17. Kitchen porters in clean and tidy uniforms while meals are being served in the wards.	3.09±0.10	2.71±0.08	0.38	3.50 (159)	0.001*
OVERALL	**2.83±0.06**	**2.91±0.07**	**-0.08**	**-1.80 (159)**	**0.073**

* *p*-value <0.01

** *p*-value <0.001

The IPA grid of the hospital food service attributes

The overall IPA grid shown in Figure 2 revealed that four indicators, were in the "Possible overkill" quadrant, while two indicators, were in the "Keep up the good work" quadrant. There were five indicators that fell into the "Low priority" quadrant. Finally, six indications fell in the "Concentrate here" quadrant.

"*Concentrate here*" quadrant

Figure 2 illustrates that six out of seventeen indicators (n=6, 35.3%) are positioned within the "concentrate here" quadrant. These indicators were primarily related to food production and distribution management including utilisation of a variety of ingredients (indicator 5), kitchen staff in neat and clean uniforms (indicator 7), verify if any infectious diseases are present among the staffs (indicator 8), nutritional analysis of menu (indicator 9), and menu evaluation (indicator 10). Additionally, one indicator was associated with patient or customer service management, specifically regarding kitchen porters in clean and tidy uniforms while meals are being served in the wards (indicator 17). The findings highlight notable underperformance in these areas of hospital food service, indicating a need for immediate quality improvement initiatives.

"*Keep it up a good work*" quadrant

The indicators classified within this quadrant were deemed highly important and demonstrated effective

performance. As shown in Figure 2, these indicators included the utilisation of standardised recipe in the development of normal and therapeutic menus (indicator 12), as well as the providing a variety of food choices for patients with a normal diet (indicator 16).

***"Possible overkill"* quadrant**

The indicators positioned within this quadrant were perceived by staff as having relatively lower importance. Despite this, their performance was satisfactory and exceeded basic expectations. This quadrant encompassed indicators such as establishment of standards for nutritional recommendations and menu planning (indicator 11), monitoring the cleanliness of food production and assembly areas (indicator 13), overall patient/customer satisfaction (indicator 14), and overall food quality and taste (indicator 15).

***"Low-priority"* quadrant**

The indicators classified within this quadrant were considered low priority, as they were perceived by the staff to be of lesser importance. This suggests that the indicators represent in this quadrant are not recognized as critical areas requiring quality improvement. The indicators in this category included reviewing the contract's specification/ standard of procedure (SOP) periodically (indicator 1), systematisation of the diet ordering process (indicator 2), existence of purchasing and ordering standards and procedures (indicator 3), inspection of all food ingredients at all points (e.g. receiving, storing, food preparation, etc.) (indicator 4), and temperature control of raw materials and storage area (indicator 6)

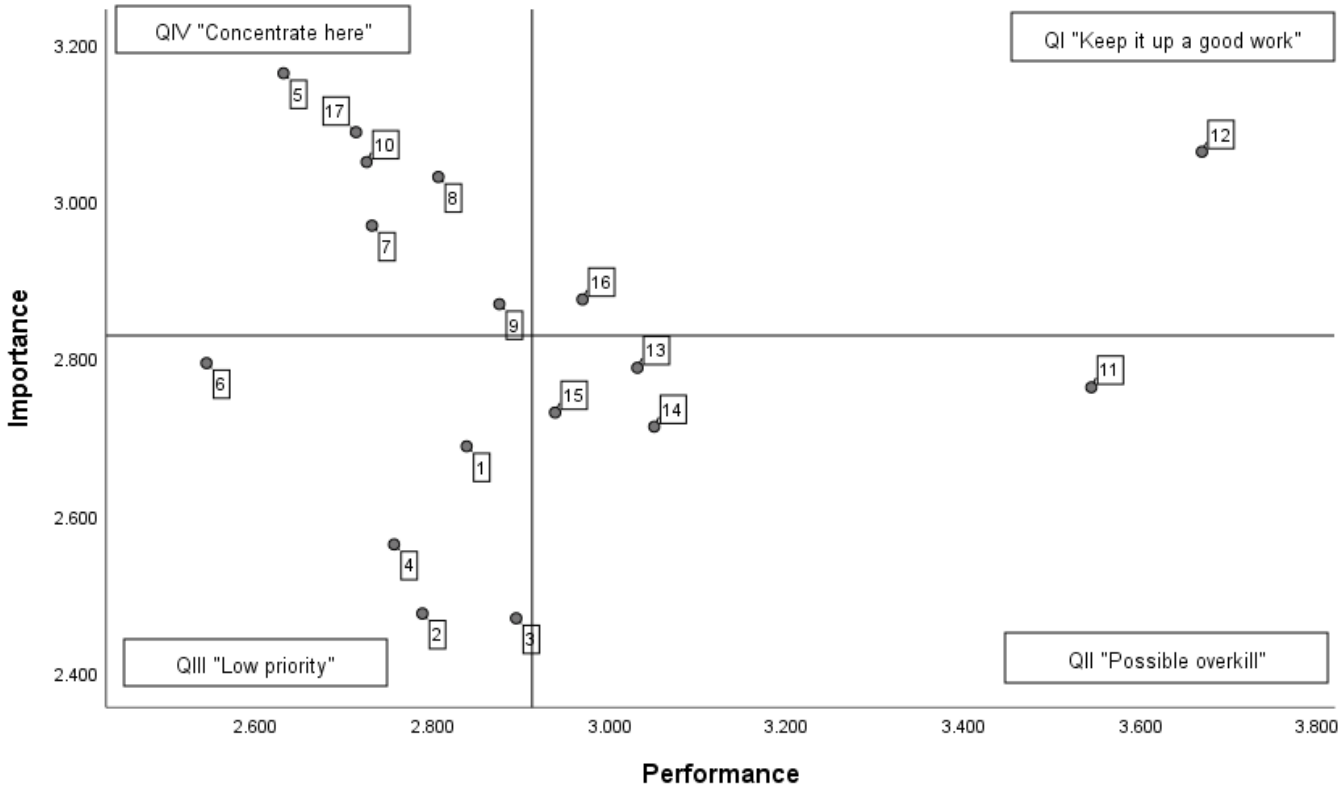

Figure 2: The overall IPA grid for hospital food service attributes

DISCUSSIONS

The present study identified a significant difference between food service staff evaluations of the hospital food service performance and their perceptions of the importance of various indicators. Specifically, the gap analysis revealed that only six out of seventeen indicators were rated as more important than their corresponding performance scores. This misalignment underscores the urgent need for targeted quality improvement initiatives to address underperforming yet high-priority areas.

These findings are consistent with previous research by Lee (2016) reporting significant differences between perceived importance and actual performance across 27 food service items. This highlights critical operational weaknesses that could impact food safety and meal quality. Similarly, Song and Bae (2013) found that the importance scores exceeded performance ratings for 22 items in South Korean hospitals, reflecting systematic

weakness in food service operations. These results reinforce the importance of aligning performance improvements with staff perceptions of priority indicators. Addressing these gaps may enhance not only food service efficiency and safety but also patient satisfaction and clinical outcomes.

This study also highlights the importance of enhancing food quality through improvements in hospital menu planning. A key recommendation is the increased use of diverse, nutrient-rich ingredients to improve both the nutritional profile and appeal of patient meals. Supporting this, Manimaran et al. (2025) found that visually appealing meals incorporating colourful vegetables like mustard greens, broccoli, and cabbage improved patient appetite and reduced food waste in Malaysian hospitals.

Moreover, the study emphasizes the need for routine nutritional analysis and menu evaluation. Bélanger et al. (2023) argued that patient perceptions of meal quality depend not only on nutritional content but also on menu cycle duration and the use of local, seasonal ingredients. Evidence from Canada further illustrates the issue: Trang et al. (2015) found that many hospital menus failed to meet dietary recommendations for calories and protein, while Barcina-Pérez et al. (2023) reported consistent deficiencies in vitamins E and D, and magnesium. These findings call for continuous monitoring, regular updates to hospital diet manuals, and procurement policies aligned with national nutritional standards to ensure the adequacy and effectiveness of patient meals.

Beyond menu quality, the study identifies personnel hygiene as another area requiring improvement. Indicators related to the cleanliness of kitchen staff and porters, as well as regular health screening for infectious diseases, were found to be lacking—especially during meal distribution in patient wards. While Elmadbouly et al. (2017) reported moderate knowledge and practices concerning personal hygiene among hospital food service staff in Makkah, the study emphasized gaps in sanitation protocols and food-borne disease prevention. Likewise, Salam et al. (2021) highlighted a complete absence of structured food hygiene or HACCP training in Sudanese hospitals.

These results stress the need for continuous food safety and hygiene training to uphold food service standards in healthcare environments. Structured, mandatory training programs—ideally integrated into hospital continuing professional development (CPD) systems—are vital for reinforcing food safety principles and ensuring consistent application of best practices. Such capacity-building measures are essential to reduce foodborne illness risk and comply with national and international safety protocols.

The findings of this study carry important implications at both organizational and policy levels. Addressing the gaps between staff expectations and actual performance requires the establishment of structured quality assurance mechanisms. Hospitals should consider forming dedicated Food Service Quality Committees and adopting established frameworks such as the Malaysian Food Service Quality (MyFoSQ) system (MOH Malaysia, 2018) to systematically monitor and improve service delivery.

Policy updates should also focus on enhancing menu diversity in line with the Malaysian Dietary Guidelines and global recommendations (NCCFN, 2020; WHO, 2019). Moreover, implementing consistent and mandatory hygiene training and certifications supported by administrative oversight and sufficient resource allocation—can ensure sustainable improvement across food service operations. These changes are necessary to elevate the overall standard of healthcare delivery through improved food safety and patient nutrition.

Several limitations were encountered during data collection. Although the online questionnaire method facilitated accessibility, the response rate was lower than anticipated, requiring multiple follow-ups to encourage participation. Additionally, some respondents demonstrated limited understanding of the IPA framework, particularly in distinguishing between the 'importance' and 'performance' constructs. To address this, the researcher provided explanations to ensure consistent interpretation of the scales. These limitations suggest the need for more extensive training or guidance when applying IPA in future studies.

CONCLUSIONS

This study emphasizes the need for targeted quality improvements in hospital food service operations, particularly in the areas of food production, distribution and patient service management. It highlights the policy and managerial importance of addressing key performance gaps through strategic interventions. Future efforts should focus on ingredient variety, menu evaluation, hygiene practices among food service personnel, and health monitoring. A proposed Continuous Quality Improvement (CQI) model featuring performance audits, staff training, patient feedback mechanisms, and alignment with frameworks such as Malaysian Food Service Quality (MyFoSQ) can support sustained enhancements in food service quality and overall healthcare standards in Malaysian hospitals.

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ORIGINAL ARTICLE

Noise Exposure and Hearing Health: A Study of Baristas' Perception, Knowledge, and Attitudes in Malaysian Speciality Coffee Shops

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ABSTRACT

Background: Noise-induced hearing loss (NIHL) is a significant occupational health issue globally, with service industry workers, including baristas, often overlooked despite their exposure to potentially hazardous noise levels. This study aimed to measure noise levels in speciality coffee shops within the Kuantan municipality area and evaluate baristas' knowledge, attitudes, and perceptions of noise and its impacts. **Method**: Noise levels were assessed using the NIOSH Sound Level Meter App during typical workdays, while 30 baristas completed questionnaires structured around the Health Belief Model (HBM)**. Results:** Noise levels measured in the cafés were within permissible limits. Baristas predominantly perceived noise as enhancing workplace ambience, with limited awareness of its adverse effects. Notably, none of the baristas reported ever using hearing protection devices (HPDs), highlighting a critical gap in preventive practices. Gender differences were observed in perceived susceptibility to hearing loss, with females reporting significantly higher scores than males ($p = 0.02$). However, no significant gender differences were found in other health belief domains. **Conclusion:** These results highlight the need for targeted educational interventions to raise awareness of noise hazards and promote safer work practices among baristas. The study contributes to the broader understanding of occupational health in non-industrial sectors, highlighting the importance of addressing noise exposure in the growing speciality coffee industry.

INTRODUCTION

Noise-induced hearing loss (NIHL) is a leading occupational health concern globally, affecting over 500 million people worldwide, with at least 25% of workers exposed to hazardous noise levels (Phillips et al., 2019; World Health Organisation [WHO], 2021; Jo & Baek, 2024). NIHL remains a significant occupational health issue in Malaysia. In 2023, of the 11,747 occupational disease cases reported to the Department of Occupational Safety and Health (DOSH), 57.5% involved noise-induced hearing disorders, including NIHL and permanent hearing impairment, significantly exceeding the prevalence of musculoskeletal disorders (5.9%) and skin diseases (0.4%) (Department of Statistics Malaysia [DOSM], 2023; DOSH, 2024).

Extensive research has been conducted to evaluate the risks of NIHL among workers in industries such as manufacturing, construction, mining, and transportation, where prolonged exposure to machinery noise is a well-documented hazard (Chadha et al., 2021). However, service industries like hospitality have received comparatively less attention despite evidence showing that employees, including baristas and chefs, frequently encounter noise levels exceeding permissible exposure limits (Green & Anthony, 2015; Al-Arja & Awadallah, 2020; Li et al., 2022; Mekonnen et al., 2022). This issue is particularly pertinent in Malaysia, where the speciality coffee industry has experienced substantial growth over the past decade, leading to a significant increase in the number of baristas potentially exposed to harmful noise (Lee et al., 2018; Ong, 2021; Foo, 2023).

Cafés are characterised by elevated noise levels, typically ranging from 66.5 to 81.9 dBA during operating hours and often surpassing Occupational Safety and Health (OSHA's) 90-dBA limit during peak periods (Al-Arja & Awadallah, 2020; Zelem et al., 2023). These high noise levels arise from various sources, including coffee-making equipment, the hum of espresso machines, grinding, steaming, customer conversations, background music, clinking dinnerware, and kitchen appliances (Kelly et al., 2012; Pienkowski, 2021). Modern interior design trends, such as industrial-style layouts, open kitchens, and the use of reflective materials like concrete, steel, and wood, further exacerbate the problem by creating reverberant spaces (Rusnock & Bush, 2012; Eichwald et al., 2022). Baristas, in particular, are at high risk due to their prolonged exposure to these noises.

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Other than hearing loss, the impact of elevated noise levels could lead to stress, reduced job satisfaction, and impaired social interactions, which could negatively affect workers' attitudes, behaviours, and overall well-being (Lao et al., 2013; Pursley & Saunders, 2016; Abbasi et al., 2024). However, workers in service industries often normalise elevated noise levels, underestimating the associated risks and adopting fewer protective measures (Goines & Hagler, 2022). Conversely, those with greater awareness of noise hazards and proactive attitudes are more likely to use hearing protection devices (HPDs) to safeguard their hearing (Ismail, 2013; Vosoughi et al., 2022; Guo et al., 2024).

Despite the rapid growth of Malaysia's speciality coffee industry, research on café environmental noise and baristas' perceptions, knowledge, and attitudes toward noise exposure remains limited. This study aims to measure noise levels in speciality coffee shops in Kuantan and evaluate baristas' knowledge, attitudes, and perceptions regarding noise and its impact. The findings are intended to raise awareness of occupational noise hazards and suggest educational strategies to promote a safer work environment.

METHODOLOGY

This study employed a cross-sectional design, conducted in two parts: (1) measuring noise levels in cafés and (2) administering a set of questionnaires to assess baristas' perception, knowledge, and attitudes toward noise.

Study Design and Sampling

Participants were recruited via convenience sampling based on the following inclusion criteria: current baristas in Kuantan, aged 18 or older, and capable of completing the questionnaire. Exclusion criteria excluded non-baristas, individuals under 18 years old, those with language or literacy barriers, and non-residents of Kuantan municipality, Pahang, Malaysia. A total of 30 cafés were approached, with 16 agreeing to participate, including two international chains, anonymised as Cafés 1–16. Power calculations ensured an adequate sample size.

Noise Measurement Tool

Noise levels were measured using the National Institute for Occupational Safety and Health (NIOSH) Sound Level Meter (SLM) smartphone application installed on iPhones. This application was chosen for its reliability, accessibility, and comprehensive features designed specifically for occupational noise assessment (Murphy & King, 2016; Lee & Hampton, 2024). The app's availability on iOS platforms makes it a practical alternative to conventional SLMs, which are more expensive.

The app provides real-time readings of key metrics, including A-weighted equivalent sound level (LAeq), C-weighted peak sound pressure level (LCpeak), time-weighted average (TWA), and noise exposure dose. It supports adjustable weighting (A, C, or Z) and allows data saving and sharing. With an accuracy of ±2 dBA and global positioning system (GPS) functionality for geospatial mapping, the app is effective for occupational noise studies (Kardous & Shaw, 2014; Celestina et al., 2018; Jacobs et al., 2020).

Noise Measurement Procedure

Noise levels in the cafés were measured over 15-minute periods, following NIOSH SLM App recommendations and local noise measurement guidelines (*Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation*, [ICOP], 2019). Measurements were taken in baristas' main workspaces during peak lunch hours (11:00 AM–2:00 PM) to represent typical noise exposure.

Using a smartphone with the NIOSH SLM App, microphones were angled at 45° to minimise interference, with devices either handheld or placed on a soft surface. Handheld measurements maintained a 1 m distance from noise sources at a height of 1 m. The app recorded one-second time-history data, including short-term and average LAeq, maximum and minimum noise levels, and standard deviations.

Each café was visited twice, with initial 10-minute noise samples screened for consistency. Spatial and operational factors were noted to contextualise the noise data, with average LAeq values serving as the primary metric for analysis.

Questionnaire Administration

The study utilised a questionnaire adapted from validated tools (Saunders et al., 2014; Pursley & Saunders, 2016) with the authors' permission. It comprised three sections: demographics and HPD use (Section A); noise perception impacts (Section B), with 5 positive and 8 negative items on a 5-point Likert scale; and knowledge (16 items) and attitudes (22 items) on hearing loss prevention (Section C), structured using six Health Belief Model (HBM) domains. Expert face validation ensured clarity and strong internal consistency was confirmed (Cronbach's α: perception 0.88, knowledge 0.93, attitudes 0.76).

Participants were briefed on the study objectives and consent was obtained before being given a QR Code to access the Google Form questionnaire to complete. Clarifications were encouraged to ensure accurate responses. Data was analysed using SPSS (Version 20).

RESULTS

Demographic data

A total of 30 participants, evenly split by gender (50% male, 50% female), aged 18–35 years (mean age 24.63 ± 3.91), participated in the study. Half were aged 24–29 years, followed by 18–23 years (36.7%) and 30–35 years (13.3%). Most participants (70%) had worked as café workers for about a year. None of the participants reported using hearing protection devices while working or when exposed to loud noise.

Noise Level Measured in the Cafés

The average noise levels recorded at 16 cafés in Kuantan are shown in Table 1.

Table 1: The average noise level measured at 16 cafés in Kuantan

Café	Average Recorded Noise Level (dBA)
1	72.5
2	68.9
3	69.2
4	68.2
5	76.6
6	76.9
7	74.4
8	81.4
9	69.9
10	73.2
11	73.6
12	67.7
13	76.0
14	75.2
15	70.3
16	73.1
Mean	72.94

Table 1 presents the average noise levels recorded at 16 cafés in Kuantan, with values ranging from 67.7 to 81.4 dBA. The mean noise level across all 16 cafés was 72.94 dBA, with 50% of cafés recording noise levels between 68.0 dBA and 76.0 dBA, reflecting moderate to high sound levels typical of café environments. Café 12 recorded the lowest noise level at 67.7 dBA, which falls within a range considered less likely to pose significant auditory risks. In contrast, Café 8 recorded the highest noise level at 81.4 dBA, approaching levels linked to elevated occupational noise exposure, likely due to its open design and location on a busy city-centre road, both contributing to increased ambient noise. However, all recorded noise levels remained below the exposure limits set by the Malaysian noise regulations (DOSH, 2019).

Perceptions of the Positive and Negative Impacts of Café Sounds

Tables 2 and 3 summarise baristas' perceptions of both the positive and negative impacts of café sounds.

Table 2: Perceptions of the Positive Impacts of Café Sounds (N = 30)

The sounds in the café…	Strongly Agree (1)	Agree (2)	Neutral (3)	Disagree (4)	Strongly Disagree (5)
make for a fun workplace	11 (36.7%)	12 (40.0%)	6 (20.0%)	1 (3.3%)	0 (0%)
create a good atmosphere for customers	10 (33.3%)	11 (36.7%)	6 (20.0%)	2 (6.7%)	1 (3.3%)
make for an exciting place to be	14 (46.7%)	5 (16.7%)	8 (26.7%)	2 (6.7%)	1 (3.3%)
help customers relax	10 (33.3%)	5 (16.7%)	10 (33.3%)	3 (10.0%)	2 (6.7%)
help me focus on my work	10 (33.3%)	6 (20.0%)	10 (33.3%)	4 (13.3%)	0 (0%)

Table 2 shows that baristas largely perceived café sounds as enhancing both the workplace environment and customer experience. A substantial majority, 76.7% of baristas (36.7% strongly agree; 40.0% agree), felt that café sounds contributed to a fun workplace. Similarly, 70% (33.3% strongly agree; 36.7% agree) believed that these sounds fostered a positive atmosphere for customers. Subsequently, 63.4% (46.7% strongly agree; 16.7% agree) found these sounds exciting, highlighting their role in creating an engaging and lively environment.

However, the perceived benefit of café sounds for relaxation and focus were less conclusive. While half of the respondents (50%) agreed that café sounds helped customers relax, the remaining half were neutral or disagreed. Similarly, 53.3% reported that these sounds helped their concentration, but 46.7% expressed neutral or opposing views. This suggests that the positive impacts of café sounds may depend on individual preferences and situational factors.

Table 3: Perceptions of the Negative Impacts of Café Sounds (N = 30)

The sounds in the café…	Strongly Agree (1)	Agree (2)	Neutral (3)	Disagree (4)	Strongly Disagree (5)
make it difficult to concentrate	1 (3.3%)	6 (20.0%)	9 (30.0%)	5 (16.7%)	9 (30.0%)
make me feel stressed	3 (10.0%)	0 (0%)	9 (30.0%)	4 (13.3%)	14 (46.7%)
might affect my hearing	3 (10.0%)	2 (6.7%)	10 (33.3%)	5 (16.7%)	10 (33.3%)
affect my ability to do my work	2 (6.7%)	4 (13.3%)	6 (20.0%)	6 (20.0%)	12 (40.0%)
make it difficult to hear co-workers	2 (6.7%)	7 (23.3%)	7 (23.3%)	6 (20.0%)	8 (26.7%)
make it difficult to hear customers	2 (6.7%)	5 (16.7%)	12 (40.0%)	6 (20.0%)	5 (16.7%)
cafe make it difficult to hear alerts/warnings/signals	2 (6.7%)	2 (6.7%)	11 (36.7%)	9 (30.0%)	6 (20.0%)
might affect customers' hearing	3 (10.0%)	3 (10.0%)	10 (33.3%)	7 (23.3%)	7 (23.3%)

The perceived negative impacts of café sounds were less pronounced but still notable, as shown in Table 3. Only 23.3% (3.3% strongly agree; 20% agree) of respondents agreed that café sounds made it difficult to concentrate, whereas nearly half (46.7%) either disagreed or strongly disagreed. Stress-related concerns were minimal, with 60.0% dismissing the notion that café sounds caused stress. Communication challenges emerged as a potential issue: Hearing Coworkers: 30.0% found it difficult to hear colleagues, while 46.7% disagreed; Hearing Customers: 23.4% noted difficulty in hearing customers, with 36.7% reporting no such issues; Hearing Alerts/Warnings: Only 13.4% struggled with auditory alerts, while 50.0% disagreed. Concerns about hearing impacts were also relatively low, with 16.7% agreeing that café sounds might affect hearing but 50.0% dismissing such risks.

Baristas' knowledge towards noise based on gender

A Independent-Samples t-test was conducted to compare knowledge scores between male and female café workers. Before performing the t-test, Q-Q plots were examined to assess the normality assumption, revealing that knowledge scores were approximately normally distributed for both groups. Additionally, Levene's test indicated that the variances were equal across the two groups. The t-test revealed no statistically significant difference in knowledge scores between genders, t (28) = 0.155, p = 0.878. Overall, most respondents, regardless of gender, scored less than 50%, indicating limited knowledge regarding noise and hearing, with only 5 out of 30 respondents scoring higher than 50%.

The analysis revealed no statistically significant difference in knowledge scores between male and female baristas. Most respondents, regardless of gender, scored below 50%, indicating a general lack of knowledge about noise and hearing. Only 5 of 30 respondents scored above 50%. Female baristas revealed slightly higher mean knowledge score (M = 5.60, SD = 3.38) compared to males (M = 5.40, SD = 3.68), with a mean difference of 0.20 (95% CI: -2.44 to 2.84). However, this difference was not statistically significant, t (28) = 0.15, p = 0.87, indicating that gender does not appear to influence knowledge levels in this sample.

Attitudes toward hearing loss prevention were analysed across six domains of the HBM: susceptibility, severity, barriers, benefits, self-efficacy, and cues to action. A Shapiro-Wilk test was conducted to assess the normality of each domain's distribution. Three domains (susceptibility, barriers, and self-efficacy) were normally distributed and analysed using independent-sample t-tests. The other three domains (severity, benefits, and cues to action) violated the normality assumption and were analysed using the Mann-Whitney U test. A significant gender difference was found in perceived susceptibility to hearing loss, with female baristas reporting a higher mean score (M = 15.00, SD = 11.50) compared to males (M = 4.33, SD = 12.37), yielding a mean difference of 10.67 (95% CI: 1.73, 19.60). The difference was statistically significant (t (28) = 2.45, p = 0.02), suggesting that females perceive themselves as more vulnerable to hearing loss compared to males.

For other HBM domains, no statistically significant differences were observed. Perceived severity had mean ranks of 17.03 for females and 13.97 for males (Z = −0.98, p = 0.33); perceived benefits (females: mean rank = 16.37, males: mean rank = 14.63, Z = −0.54, p = 0.59), perceived barriers (mean difference = 6.11, t(28) = 0.74, p = 0.46), perceived self-efficacy (mean difference = 7.08, t(28) = 0.82, p = 0.42), and perceived cues to action (females: mean rank = 17.90, males: mean rank = 13.10, Z = −1.52, p = 0.13) were similar across genders.

DISCUSSIONS

This study highlights a multifaceted relationship between café noise levels, workers' perceptions, and health risks. While noise levels (67.7–81.4 dBA) across 16 cafés fell below hazardous thresholds set by Malaysian standards, prolonged exposure to peak levels, such as 81.4 dBA at Café 8 or occasional spikes above 90 dB from equipment, may pose auditory risks for baristas and other staff. These findings align with previous research in similar hospitality environments which found that even intermittent or peak noise exposures can contribute to NIHL (To & Chung, 2014; Green & Anthony, 2015; Pursley & Saunders, 2016; Li et al., 2022; Mekonnen et al., 2022). Such exposures, even if brief, may have cumulative effects over time, particularly in settings where staff work long shifts without hearing protection. Thus, these findings highlight the importance of implementing preventive measures and promoting hearing health education, even in workplaces that are not traditionally considered high-risk for occupational noise exposure.

Café noise variability highlights the potential for auditory discomfort during peak periods, exacerbated by prolonged exposure and cumulative lifestyle risks, such as attending music events without HPDs (Kelly et al., 2012; Alzahrani et al., 2018; Mina et al., 2023). Addressing these occupational and lifestyle exposures is critical for long-term hearing health.

The current study suggests that the NIOSH SLM apps can be utilised as one of the alternative screening tools in some settings. Similar findings were reported by previous studies, particularly when noise levels are stable and exceed 75 dBA (Kardous & Shaw, 2014; Celestina et al., 2018; Jacobs et al., 2020; Lee & Hampton, 2024).

Baristas perceived café sounds as positive for ambience and workplace enjoyment but reported challenges with communication and situational awareness. Despite these perceptions, all participants lacked awareness of noise-related health risks, and none reported using HPDs. Limited training in noise hazards, typical in the service sector, likely contributes to this gap, echoing findings from previous studies (Keppler et al., 2015). Educational interventions tailored to baristas could enhance noise risk awareness and encourage protective behaviours, reducing the risk of NIHL. Previous research has shown that ongoing hearing education programs effectively improve knowledge and preventive practices (Ismail, 2013; Saunders et al., 2014; McCullagh et al., 2020; Supramanian et al., 2023; Bramati et al., 2024).

Female baristas in this study reported a higher perceived susceptibility to hearing risks compared to males, consistent with previous research suggesting women are more likely to engage in health-promoting behaviours (Liu et al., 2017; Luquis & Kensinger, 2018). In contrast, men are inclined to adopt unhealthy attitudes and are less likely to perceive themselves as being at risk of illness (Korin et al., 2013; Sasaki et al., 2022). These findings stress the importance of a comprehensive approach integrating workplace training and tailored interventions to mitigate the risks of NIHL in service industry settings. Additionally, recognising and addressing gender-specific needs in the planning and delivery of hearing education programs can enhance the effectiveness of these strategies and ensure inclusivity.

Despite its valuable contributions, this study has several limitations worth considering for future research. The small sample size and geographic focus on a single town limit the generalisability of the findings to other baristas and cafés in Malaysia. The use of an online questionnaire, requiring baristas to scan a QR code, likely reduced the response rate due to their busy schedules. Alternative distribution methods, such as WhatsApp or email, may improve participation.

This study used the NIOSH SLM app for area measurement, which, although, validated, does not offer the precision calibration of Class 1 and 2 SLMs. Future studies should address this by employing standardized devices compliant with ANSI and IEC standards to enhance the applicability of the findings. Personal dosimetry is recommended to assess the cumulative noise impact on the worker, helping to determine if they are being exposed to potentially harmful noise levels.

CONCLUSION

This study determined that although café noise levels measured during peak hours were below hazardous thresholds, baristas demonstrated limited knowledge and low perceived risk of hearing loss. This highlights the need for targeted hearing health education to promote awareness and protective practices, even in relatively low-noise environments.

Future research should consider using standardized noise measurement instruments and personal exposure monitoring to enhance accuracy. Integrating perspective, given the limited knowledge and low perceived risk of hearing loss among baristas, reviewing noise exposure standards for service industries and integrating gender-sensitive approaches into hearing conservation programs might be worth considering in creating safer and healthier workplaces.

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ORIGINAL ARTICLE

Integrated Biological and Behavioural Surveillance (IBBS) Survey 2022: Risk Behaviours among People Who Inject Drugs (PWID) in Malaysia

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ABSTRACT

Background: People who inject drugs (PWID) are among the key populations most affected by the HIV epidemic in Malaysia. The objective of this study was to examine the risk behaviours and prevalence of human immunodeficiency virus (HIV) among PWID. **Methods:** Respondent-driven sampling (RDS) was employed to recruit PWID for the Integrated Biological and Behavioural Surveillance (IBBS) survey conducted between July and December 2022. Participants completed online behavioural surveys and underwent rapid HIV testing. **Results:** 824 respondents participated in this study. 96.9% of respondents reported using clean needles and syringes in their last injection. Most respondents (96.7%) also reported they had no problem getting access to sterile needles and syringes. Only 9.6% of respondents stated that they shared needles and syringes with friends in the past 3 months. A total of 54.6% of respondents are enrolled in the Methadone Maintenance Therapy (MMT). It is concerning that 90.0% of respondents who reported being sexually active had sex without using a condom. The HIV prevalence among PWID was 7.5%. **Conclusion:** In Malaysia, HIV prevalence among PWID has significantly declined over the past decade, largely in line with reduced risk behaviours, particularly increased use of safe needles and syringes. To sustain this downward trend, continued surveillance and prevention efforts are essential. Additionally, prevention strategies should also aim to promote safer sexual practices among PWID.

INTRODUCTION

As of the end of 2018, the estimated number of people who inject drugs (PWID) in Malaysia was approximately 75,000. (MOH, 2018). The 2017 Integrated Biological and Behavioural Surveillance (IBBS) survey among male PWID reported an HIV prevalence of 13.4%, making it the second highest among all identified high-risk groups (MOH, 2019).

PWID was initially responsible for the HIV epidemic in Malaysia primarily via the sharing of injecting paraphernalia, however, in the past decade, sexual transmission has emerged as the main mode of transmission (MOH, 2021). Nevertheless, continued research on HIV risk among PWID remains crucial to ultimately ending the HIV epidemic within this population.

Since 2009, Malaysia has added the IBBS survey to its national HIV surveillance system in order to track the trajectory and pattern of the HIV epidemic. This study, carried out every two to three years, aims to evaluate the local trend of the HIV epidemic in the country and to identify the factors that may have an impact on how the epidemic develops in the region and population under study. The objective of this study was to examine the risk behaviours and prevalence of HIV among PWID.

MATERIALS AND METHODS

Study Setting and Sample Size

The study was conducted among male PWID in eight states in Malaysia. PWID were enrolled based on predefined inclusion criteria: individuals aged 18 years or older, with a history of injecting drugs for at least six months prior to the survey date, able to understand either Bahasa Malaysia or English, and willing to provide informed consent. The target sample size was calculated to be 900 assuming 95% confidence level with 5% margin error and 50% response rate.

Study Design

Respondent-driven sampling (RDS) was used to recruit respondents into the study because it is specifically designed to avoid many of the biases and issues of other chain referral system, such as snowballing. RDS has been demonstrated to be an effective sampling approach for hidden and difficult to reach or invisible populations that have no sampling frame (Heckathorn, 1997).

In this study, respondents included i) seeds act as the initial respondents for the recruitment process, and ii) new survey respondents recruited by the previous survey respondents. About three to five seeds were pre-identified by the person in charge for each study site, but only one

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seed was planted at a time to initiate the recruiting process. In the event that no new recruits were found or the rate of recruiting was too slow, new seed was planted. In order to ensure diversity, seeds were chosen, to the greatest extent possible, based on geographic, demographic and key outcome variables such as HIV status, socio-economic status, age, gender and their acquaintance with diverse people. In this study, eight seeds were use in the recruitment process.

Each respondent was subjected to eligibility screening using screening questions before enrolment to eliminate those who were outside the study's target population. After completing the online survey and blood test, each seed received three quick response (QR) codes to use in recruiting the initial wave of respondents from his network of peers. The QR code was valid for five days. Each wave of responders recruited the next wave until the desired sample size was reached.

After completing the online survey and blood test, respondents were given an incentive of RM40. This incentive was provided to respondents as a token of appreciation for the transport, time/effort and costs that they had incurred whilst taking part in this study. They also received RM10 as an additional incentive for each successful referral (maximum of RM30).

This study comprised two parts. The first part consisted of a behavioural survey that was carried out using a self-administered online questionnaire survey via a web-based platform. After completing the online survey, respondents were instructed to go to the community-based testing sites of their choice for HIV blood testing. This study was registered with the Medical Research and Ethics Committee, Ministry of Health, Malaysia.

Study Instrument

The instrument used was a self-administered online questionnaire survey via web-based platform. The questionnaire was adapted from the Family Health International Guidelines for Repeated Behavioural Surveys in Population at Risk of HIV. The questionnaires were written in Bahasa Malaysia and English, which are the two main languages of Malaysia. The questionnaire contained questions about sexually transmitted infections (STI) symptoms, HIV knowledge and stigma, sexual history, injectable drugs, coverage of interventions, testing, and treatment, and sociodemographic traits. No personal information was asked to maintain anonymity.

Statistical Analysis

Statistical analysis was done using the Statistical Package for Social Sciences (SPSS 26.0) software. Data was entered, cleaned and checked before data analysis. Frequencies and simple associations were calculated**.**

RESULTS

Socio-Demographic Characteristics

The socio-demographic characteristics of the PWID respondents are summarized in Table 1. The response rate for the study sample was 91.6%. In total, 824 male PWID participated in this study. Most respondents (40.7%) were between the ages of 40 to 49, with a median age of 42. The majority of respondents (93.9%) identified as Malay, were Muslim (96.4%), had completed at least secondary school (83.9%) and not being married (49.4%). More than half of the respondents (66.4%) claimed to have worked.

Table 1: Socio-demographic characteristics of PWID respondents

	n	%
Age		
≤ 24	10	1.2
25 - 29	27	3.3
30 - 39	250	30.3
40 - 49	335	40.7
≥ 50	202	24.5
Median age (years)	42 (21-69)	
Ethnic		
Malay	774	93.9
Chinese	15	1.8
Indian	19	2.3
Pribumi Sabah	2	0.2
Orang Asli	10	1.2
Others	4	0.5
Education		
No formal education	10	1.2
Primary	105	12.7
Secondary	691	83.9
Tertiary	18	2.2
Marital status		
Unmarried	407	49.4
Married	205	24.9
Divorced	204	24.8
Widower	8	1.0
Source of income		
Employed	547	66.4
Unemployed	218	26.5
Student	0	0.0
Others	59	7.2
Faith		
Islam	794	96.4
Buddhism	11	1.3
Hinduism	14	1.7
No religion	5	0.6
Duration of living in the city		
Median duration (years)	37 (0.1-69)	

Drug Use and Injecting Practices

The drug use and injecting practices among the PWID respondents are displayed in Table 2. The majority of PWID respondents reported using and injecting drugs for more than or equal to 5 years. 20 years was the median age at which respondents started using drugs of any type, whereas the median age at which respondents started injecting drugs was 25. The most frequently injected drug was reportedly heroin (92.1%). The majority of PWID respondents (94.5%) stated that they injected drugs no more than four times per week. About 90.4% and 96.9% of PWID, respectively, stated that they had used sterile syringes and needles within the previous three months and at their most recent injection. Most PWID respondents (96.7%) reported they had no problem getting access to sterile needles and syringes.

Table 2: Drug use and injecting practices among PWID respondents

	n	%
Duration of drug use		
≤ 1 years	1	0.1
2-4 years	7	0.8
≥ 5 years	816	99.0
Duration of injecting drug		
≤ 1 years	13	1.6
2-4 years	30	3.6
≥ 5 years	781	94.8
Types of drugs injected* *(*multiple response)*		
Heroin	759	92.1
Diazepam	32	3.9
Amphetamines	304	36.9
Suboxone/Methadone	102	12.4
Codeine	16	1.9
Opium	18	2.2
Ketamine	44	5.3
Ecstasy/Methamphetamine	153	18.6
Ketum	87	10.6
Opiates** + Others types of drugs	823	99.9
*(**refer to Heroin, Codeine, Opium & Suboxone/Methadone)*		
Injection frequency per week		
≤ 4 times	624	94.5
5 - 9 times	33	5.0
≥ 10 times	3	0.5
Median injection per day	2 (1-13)	
Injecting practices in the past 3 months		
Shared needle and syringe with friends	79	9.6
Injecting practices at last injection		
Not using a clean needle	21	3.1
Had problem getting sterile needle and syringes		
Yes	27	3.3

Sexual Practices

The sexual practices among the PWID respondents are shown in Table 3. A quarter of the PWID respondents (25.5%) reported having sex in the past 1 month and the majority of them (90.0%) reported not wearing a condom for their most recent encounter.

Table 3: Sexual practices among PWID respondents

	n	%
Had sexual intercourse in the past 1 month		
Yes	210	25.5
Used condom during last sex (N=210)		
Yes	21	10.0

Services Exposure and Utilization

The services exposure and utilization among the PWID respondents are summarized in Table 4. Regarding HIV, 93.3% of PWID respondents had ever had their blood tested for HIV. Of those, 49.0% and 33.3% had their test less than 6 months ago and 6 to 12 months ago, respectively. Almost three-quarters of the respondents (77.8%) had access to an HIV test at community based testing. A total of 45.0% of respondents claimed that their partner/spouse had also undergone the HIV testing.

Just 8.3% of respondents who self-reported having a negative or unknown HIV status had heard of pre-exposure prophylaxis (PrEP) in relation to HIV prevention. Only 36.5% of respondents stated that they would consider using PrEP in the future. The top three reasons cited by respondents who are not interested in taking PrEP are that it is too costly (35.0%), they are not interested in taking PrEP (30.0%), and they are not yet prepared for PrEP (15.0%). When it comes to HIV prevention, the majority of respondents (88.1%) favoured condoms over PrEP.

Approximately half of the respondents (54.6%) had enrolled in the MMT programme. A total of 81.4% of respondents had a Hep C blood test. As for STI, a low proportion of PWID respondents (4.5%) reported visiting a STI clinic in the past 3 months. The respondents were also asked if they had experienced STI symptoms in the past 12 months. Extreme burning pain when urinating (2.1%), rectal discharge/bleeding (0.4%) and penile ulcer (0.2%) were the most frequent STI symptoms reported by the respondents and 40.0% of them admitted using government-run facilities for treatment.

Table 4: Services exposure and utilization among PWID respondents

	n	%
Contacted by NGO outreach worker (ORW) or healthcare worker (HCW)		
Yes	754	91.5
HIV		
HIV testing		
Ever had blood tested for HIV	769	93.3
Access to HIV test*: (N=769)		
a) Government clinic	329	42.8
b) Private clinic	12	1.6
c) Community based testing	598	77.8
d) Self-testing	3	0.4
*(*multiple response)*		
Last take HIV blood test: (N=769)		
a) Less than 6 months ago	377	49.0
b) 6 to 12 months ago	256	33.3
c) more than 12 months ago	136	17.7
Regular partner/spouse taken the HIV testing: (N=769)		
Yes	346	45.0
No	250	32.5
Does not have permanent partner or spouse	173	22.5
HIV prevention		
Heard about pre-exposure prophylaxis (PrEP) (N=779)	65	8.3
Taken PrEP in the past 12 months (N=65)	2	3.1
Where get PrEP: (N=2)		
a) Private clinic	2	100
b) Pharmacy	0	0.0
c) Online	0	0.0
Interested in taking PrEP in the future (N=63)	23	36.5
Reason did not interested in taking PrEP in the future: (N=40)		
a) Not interested to take PrEP	12	30.0
b) Financial problem	1	2.5
c) Too expensive	14	35.0
d) I am not ready yet for PrEP	6	15.0
e) Afraid of stigma or rejection	3	7.5
f) Afraid of the side effects of PrEP	0	0.0
g) No risk of being infected with HIV	4	10.0
Prefer as HIV prevention: (N=779)		
a) PrEP	93	11.9
b) Condom	686	88.1
Heard about post-exposure prophylaxis (PeP) (N=779)	44	5.6
Taken PeP in the past 12 months (N=44)	1	2.3
Where get PeP: (N=1)		
a) Private clinic	0	0.0
b) Pharmacy	1	100
c) Online	0	0.0
Methadone Maintenance Therapy (MMT)		
Enrolled in MMT program	450	54.6
Still receiving MMT (N=450)	252	56.0
Hepatitis C		
Ever had blood tested for Hep C	671	81.4
Reason did not get tested*: (N=153)		
a) Did not aware about Hep C test and treatment	82	53.6
b) Don't know where to get tested	14	9.2
c) Refused to get tested	55	35.9
d) Testing facilities not available or too far	4	2.6
e) Others	8	5.2
*(*multiple response)*		
Sexually transmitted infections (STI)		
Visited STI clinic in the past 3 months	37	4.5
Experienced symptoms in the past 12 months*:		
a) Extreme burning pain when urinating	17	2.1
b) Penile ulcer	2	0.2
c) Penile discharge	0	0.0
d) Rectal discharge/bleeding	3	0.4
e) Never experienced any of those symptoms	804	97.6
*(*multiple response)*		
Action taken by respondents the last time had STI symptoms: (N=20)		
a) Did not treat	5	25.0
b) Self treated/sought advice from pharmacy	3	15.0
c) Sought treatment from government health facility	8	40.0
d) Sought treatment from private health facility	0	0.0
e) Went to traditional healer	4	20.0
f) Others	0	0.0

The findings related to access and utilization of prevention services are presented in Table 5. A total of 82.5% of PWID respondents reported having received information on HIV/STI/safer injecting use. The majority of respondents (90.4%) reported to have received new, clean needles and syringes in the past 3 months. Only 9.0% of respondents claimed they had not received any HIV prevention package in the past 3 months.

Table 5: Access and utilization of prevention services by PWID respondents

	n	%
Received information on HIV/STI/safer injecting use	680	82.5
HIV prevention services*		
Received new, clean needles or syringes	745	90.4
Received condoms and lubricants	104	12.6
Received counselling on condom use and safe sex	160	19.4
Did not receive any HIV prevention package	74	9.0
*(*multiple response)*		

Treatment Status

The treatment status among the PWID respondents are shown in Table 6. In this study, 45 respondents disclosed that they were HIV positive. Of those, 82.2% were already receiving antiretroviral therapy (ART). However, 5 respondents (13.5%) had defaulted treatment for a variety of reasons, including financial problems (20%), loss of interest in the program (20%), unable to handle ART's side effects (20%), arrested at prison or drug rehabilitation centre (20%) and others (20%). A total of 37.5% of respondents claimed that their viral load had not been suppressed.

Table 6: Treatment status among PWID respondents

	n	%
HIV status (N=769)		
Positive HIV	45	5.9
Negative HIV	716	93.1
Indeterminate	3	0.4
Don't know HIV status	5	0.7
HIV treatment		
Received ART (N=45)	37	82.2
Never on ART (N=45)	8	17.8
Still receiving ART (N=37)	32	86.5
Defaulted ART (N=37)	5	13.5
Reason defaulted ART: (N=5)		
a) Opting for other form of treatment (spiritual/alternative treatment)	0	0.0
b) Financial problem	1	20.0
c) No time to seek for regular treatment	0	0.0
d) Loss of interest in the program	1	20.0
e) Cannot tolerate the side effects of ART	1	20.0
f) Afraid of stigma or rejection	0	0.0
g) Got arrested at prison or drug rehabilitation centre	1	20.0
h) Others	1	20.0
Reason did not received ART: (N=8)		
a) Opting for other form of treatment (spiritual/alternative treatment)	0	0.0
b) Financial problem	0	0.0
c) No time to seek for regular treatment	0	0.0
d) Loss of interest in the program	3	37.5
e) Cannot tolerate the side effects of ART	0	0.0
f) Afraid of stigma or rejection	0	0.0
g) I was offered but I am not ready yet for ART	5	62.5
h) I was not offered to start treatment	0	0.0
i) Others	0	0.0
Viral load suppressed: (N=32)		
Yes	14	43.8
No	12	37.5
Not sure/Not remember	6	18.8

Awareness on HIV, Risk and Prevention Efforts

The knowledge of HIV, risk and prevention efforts among the PWID respondents are shown in Table 7. A total of 46.5% of respondents believed they were at risk of contracting HIV. Regarding HIV knowledge, 73.7% of the respondents indicated to have adequate overall knowledge on HIV. The majority of respondents (> 85%) also correctly responded to each of the five questions about their understanding of HIV but only 16.4% were aware of the concept of U=U (Undetectable=Untransmittable).

HIV Prevalence

The HIV prevalence among PWID respondents was 7.5%. Five participants in this study were found to be reactive and had never had an HIV blood test.

Table 7: Knowledge of HIV, risk and prevention efforts among PWID respondents

	n	%
Felt at risk of being infected with HIV	383	46.5
Knowledge of HIV*		
A person can reduce risk of HIV by having one faithful, uninfected partner	710	86.2
A person can reduce HIV transmission by using condom	791	96.0
A healthy looking person can have HIV	761	92.4
A person cannot become infected through mosquito bites	769	93.3
A person cannot get HIV by sharing meal with someone who is infected with HIV	772	93.7
*(*number with correct answer)*		
Score Knowledge of HIV		
5 score	607	73.7
4 score	158	19.2
3 score	30	3.6
2 score	20	2.4
1 score	6	0.7
0 score	3	0.4
(score 5=adequate knowledge, score 0-4=inadequate knowledge)		
Know about U=U (Undetectable=Untransmittable)	135	16.4

DISCUSSION

The percentage of respondents in the 24–39 age category is decreasing in comparison to prior years, indicating that PWID in Malaysia are growing older (63.1% in 2009, 59.3% in 2012, 50.2% in 2014, 46.3% in 2017 and 34.8% in 2022), while the proportion of respondents in the 40 to 50 years of age and above are increasing (37.0% in 2009, 40.7% in 2012, 49.8% in 2014, 53.7% in 2017 and 65.2% in 2022) (MOH, 2019). This might be because of the same

respondents participating in each IBBS survey cycle, which causes their age to increase in each cycle. Additionally, more young people nowadays use drugs orally, inhaled or smoked rather than injecting them.

In this study, most respondents (90.4%) claimed to have received new, clean needles and syringes in the past 3 months. In addition, 96.9% of respondents reported using clean needles and syringes in their last injection. Only 9.6% of respondents stated that they shared needles and syringes with friends in the past 3 months. This is evidence of the Harm Reduction Programme's efficacy, which was launched in 2005-2006. Needle/Syringe Exchange Programme (NSEP) and MMT are two components of this programme. The NSEP facilitated access to clean needle and syringes among the PWID. Furthermore, the median number of injections per day remained low at about 2.0 in 2012, 2014, 2017 and 2022 (MOH, 2019). Therefore, with low injection frequency and consistent use of clean needles and syringes, there is a larger likelihood of reducing the risk of HIV transmission and, in turn, the prevalence of HIV among PWID over the long term.

Similar to previous rounds of the IBBS survey, heroin continued to be the most commonly injected drug in 2022 among PWID. However, nearly all respondents (99.9%) also injected other types of drugs in addition to opioids (i.e., heroin, codeine, opium, suboxone/methadone). The use of other injectable drugs such as amphetamines and ecstasy/methamphetamine has increased in 2022 compared to 2017. This is consistent with a recent statistic from the National Anti-Drugs Agency (NADA), which showed that methamphetamine use has increased, while opiates use has decreased since 2016 (NADA, 2020). Since MMT has been used to treat opioids dependence, additional intervention strategies are required to treat other kinds of drug addiction.

In this study, the majority of PWID (90.0%) reported being sexually active and not using a condom during their last sexual encounter. Notably, 78.3% of them who did not use condoms stated that they would rather use condoms than PrEP to prevent HIV. This could be because they were still high at the time of the sexual encounter and failed to use a condom. Similar to the findings of this study, numerous studies found that a large proportion of drug users use condoms inconsistently (Mishra et al., 2014; Boltaev et al., 2013; Mahanta et al., 2008). Unfortunately, in this study, only 12.6% and 19.4% of respondents claimed to have received condoms and lubricants and counselling on safe sex and condom use, respectively. Thus, prevention initiatives should focus to increase protective sexual behaviours among PWID. Programmes to increase knowledge and focus on consistent and correct condom use, including the use of lubrication should be strengthened. Additionally, PWID must be educated about taking PrEP as a preventive measure. PrEP is highly effective for reducing the risk of getting HIV from sex by about 99% (Centres for Disease Control and Prevention, 2021) and reduced HIV transmission by 74% in injecting drug users (Choopanya et al., 2013) when taken consistently as prescribed.

By 2030, Malaysia aims to "End AIDS" by reaching the 95-95-95 target, which calls for 95% of critical populations to have had HIV testing and be aware of their results, 95% of HIV-positive individuals to be on ART, and 95% of those on treatment to have their viral load suppressed. 72.6% of PWID in this study had received HIV testing and were aware of the results. Among those who have been infected, 82.2% received ART and 43.8% adhered to their treatment regime with suppressed viral load. In order to close this gap and reach the 95-95-95 target by 2030, prevention initiatives should be prioritized, accelerated and scaled up. Additional testing strategies, including self-testing methods should be incorporated to improve testing coverage among PWID. In addition, collaboration between the government, non-governmental organizations and PWID support groups is necessary to provide an accessible supply of ART and ensure treatment adherence.

In general, 73.7% of PWID respondents indicated to have adequate overall knowledge on HIV in 2022 which is an improvement over previous year (49.7% in 2009, 53.8% in 2012, 58.3% in 2014 and 54.4% in 2017) (MOH, 2019). However, only 16.4% of respondents were aware of the concept U=U. As a result, further efforts are needed to raise awareness of this idea because better treatment literacy is also responsible for the decline in HIV-associated prevalence and risk behaviours. The findings warrant the need to empower PWID to understand and assert their basic human rights.

The prevalence of HIV among PWID in Malaysia decreased steadily from 18.9% in 2012 (MOH, 2019) to 7.5% in 2022 with consistently low injection frequency and a high percentage of safe injecting practices at the last injection. This calls for continued preventive efforts as well as surveillance to sustain the observed downward trend. Thus, it is possible to end an HIV epidemic among PWID in Malaysia in the future.

This study had several limitations that warrant careful consideration when interpreting the results. One significant limitation is the reliance on self-reported responses, which is a common practice in research within this domain. Self-reporting can introduce various biases

that may affect the accuracy of the data collected. Specifically, the findings are susceptible to reporting biases, where respondents may not accurately disclose their behaviours or experiences due to memory recall issues or misunderstanding of the questions. Additionally, there is the potential for social desirability biases, where respondents may provide answers, they believe are more acceptable or favourable in the eyes of researchers or society, rather than their true behaviours or beliefs. These biases highlight the importance of interpreting the results with caution, as they may not fully reflect the actual behaviours and attitudes of the population studied. Future research could benefit from incorporating objective measures or triangulating self-reported data with other sources to enhance the reliability of the findings.

CONCLUSION

In Malaysia, the decline in HIV prevalence among PWID over the past decade was remarkably significant and consistent with an increase in safer use of clean needles and syringes. This necessitates ongoing surveillance and preventive measures in order to maintain the observed decreased trend. In addition to injecting practices, sexual behaviours also increase the risk of HIV among PWID. Currently, sexual transmission of HIV is increasingly substituting injecting practices. Thus, prevention initiatives should also focus to increase protective sexual behaviours among PWID. Furthermore, additional intervention strategies are also needed to treat different types of drug addiction because MMT has only been used to treat opioid dependency.

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REVIEW ARTICLE

The Antiparasitic Potential of Flavonols: A Systematic Review

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ABSTRACT

Background: Parasites represent a significant global health burden, especially in tropical and subtropical regions. Despite the availability of different types of antiparasitic drugs, their harmful side effects and limited treatment options highlight the urgent need for new therapeutic alternatives. Additionally, the development of resistance to existing medications complicates treatment efficacy. Consequently, researchers are focusing on compounds found in medicinal plants, particularly flavonols, due to their potential to inhibit parasite growth effectively. This review aims to establish an evidence-based foundation for developing novel flavonol-based antiparasitic drugs that can effectively combat parasites. **Method:** The review adhered to the methodological rigor outlined by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. Specific keywords related to flavonols and antiparasitic activity were used in a systematic search of databases, including PubMed, Web of Science, ProQuest, and Science Direct. The methodological quality of the included papers was judged using the QuADS criteria. **Results:** The systematic review included 44 studies after screening 1,629 papers based on eligibility criteria. The study compiles 43 compounds and several plant extracts containing flavonols, all of which have demonstrated antiparasitic properties. **Conclusion:** This review summarizes various flavonols with differing levels of potential to combat a wide range of protozoan parasites, along with their mechanisms of action. However, more in-depth and detailed research is still needed to fully explore the potential of flavonols as future safe antiparasitic agents.

INTRODUCTION

Parasites are major contributors to human diseases globally, affecting regions such as Africa, Southeast Asia, and the Americas (Torgerson et al., 2015). They significantly impact tropical and subtropical countries like Brazil, Myanmar, Indonesia, Thailand, and Malaysia, where prevalence rates are high (Kim et al., 2016; Sahimin et al., 2016; Zanetti et al., 2021). Globally, parasitic infections are highly prevalent. For instance, the Centers for Disease Control and Prevention reported approximately 241 million cases of malaria worldwide in 2020, resulting in 627,000 deaths, mostly in sub-Saharan Africa (Global Health & Division of Parasitic Diseases, 2020). Given the global burden of parasitic diseases, the need for effective treatment options is paramount. Antiparasitic drugs play a vital role in managing these infections; however, the current market provides only a limited selection of efficacious agents (Peña-Espinoza et al., 2022), highlighting a significant gap between therapeutic availability and clinical demand. Additionally, these medications are associated with several adverse reactions, including skin rashes, gastrointestinal issues, and elevated liver enzyme levels (Starkey & Blagburn, 2022). Moreover, cases of drug resistance have been reported in certain parasites (Jain et al., 2022), further reducing the effectiveness of existing medications. This situation underscores the urgent need to discover new potential antiparasitic drugs to control parasitic infections. Researchers have investigated many plants for their biologically active compounds, known as natural products, which exhibit antiparasitic activity. These include *Cytisus villosus* Pourr, *Raillietina echinobothrida*, *Allium sativum*, and *Lippia graveolens* Kunth (Chetia & Das, 2018; Hamad, 2023; Larit et al., 2019; Quintanilla-Licea et al., 2020). Among natural products, alkaloids, flavonoids, and

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terpenoids have been studied for their antiparasitic properties, with positive outcomes (Baldim et al., 2017; Kumatia et al., 2023; Lam et al., 2020). Research has shown that flavonoids effectively inhibit multiple types of parasites. Furthermore, flavonols, a subclass of flavonoids, have demonstrated antiparasitic activities against various parasites in numerous studies. This review aims to provide an evidence-based foundation for the development of novel drugs by compiling the results of the antiparasitic actions of flavonols, serving as a reference for further research on their biological activity and clinical applications.

Parasites and parasitic diseases

Malaria is one of the most widespread parasitic infections, caused by *Plasmodium* species such as *Plasmodium knowlesi* (*P. knowlesi*), *Plasmodium vivax* (*P. vivax*), *Plasmodium falciparum* (*P. falciparum*), *Plasmodium malariae* (*P. malariae*), and *Plasmodium ovale* (*P. ovale*) (Milner, 2018). There are over 200 officially recognized *Plasmodium* species, each affecting specific host groups. However, only the five aforementioned species typically infect humans and cause malaria worldwide (Sato, 2021). Between 2013 and 2017, Malaysia documented 16,500 malaria cases, with the majority occurring in Sarawak (34.4%) and Sabah (43.3%) (Hussin et al., 2020). Currently, the predominant species in Malaysia is *P. knowlesi*, responsible for simian malaria (Chin et al., 2020).

African sleeping sickness, also known as Trypanosomiasis, is an infectious disease transmitted by tsetse flies and caused by the parasite *Trypanosoma* species (Hollingshead & Bermudez, 2024). Conversely, *Trypanosoma cruzi* (*T. cruzi*) causes Chagas disease, also known as American trypanosomiasis, which affects thousands of people. The parasite spreads through the bitten area or mucous membranes of a mammalian host when contaminated vector feces gain entry. Additional transmission routes include blood transfusions, organ transplants, ingestion of contaminated food or drink, and transmission from mother to fetus during pregnancy (Bern et al., 2019).

Protozoans belonging to the genus *Leishmania* cause the vector-borne disease leishmaniasis, which primarily affects tropical and subtropical regions. According to the World Health Organization (WHO), an estimated 700,000 to 1 million individuals become infected each year. However, only a small proportion of those infected develop the illness, with 20,000–30,000 eventually succumbing to it (Steverding, 2017).

Entamoeba histolytica (*E. histolytica*), the causative agent of amoebiasis, is one of the most lethal parasitic infections worldwide. It is estimated to affect up to 50 million people, predominantly in impoverished regions, leading to over 100,000 deaths annually (Kantor et al., 2018). Due to its resistance to environmental changes and ease of transmission, the cyst form ensures the survival of the species. The immune system or antibiotic therapy cannot eradicate the infection from cysts because of their extreme resistance. Amoebic infection arises when water, sanitation, and hygiene practices are inadequate. Mature cysts are excreted in the host's feces and spread to others through fecal-oral transmission via contaminated food or drink or direct contact (Guillén, 2023).

Toxoplasma gondii (*T. gondii*) causes toxoplasmosis, a neglected parasitic illness that affects people worldwide. This parasite can be transmitted through the consumption of raw or undercooked meat, polluted soil, tainted water, or contaminated food (Abugri et al., 2023).

Flavonoids

Flavonoids, naturally occuring polyphenolic compounds, are byproducts of plant extraction found in various plant sections. Vegetables utilize flavonoids to thrive and protect themselves against pathogens (Panche et al., 2016). While flavonoids are present in a variety of foods and drinks, including beer, wine, and tea, the highest natural flavonoid content is generally found in vegetables, flowers, fruits, and seeds (Dias et al., 2021). Flavonoids are water-soluble phenylpropanoids with a C6-C3-C6 carbon skeleton, consisting of a 3-carbon heterocyclic ring connected to two 6-carbon benzene rings (A and B). These compounds are categorized into six main groups based on their chemical structure: flavones, flavonols, isoflavones, flavanones, flavan-3-ols, and anthocyanins (Dias et al., 2021) (Figure 1).

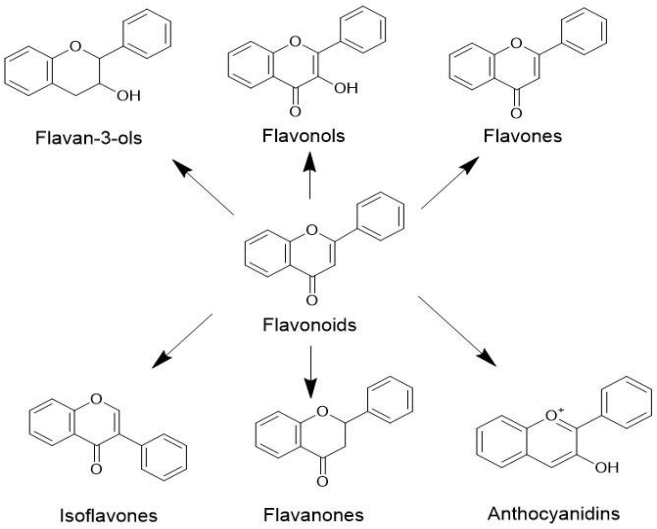

Figure 1: Flavonoids and their subclasses

However, Tsuchiya (2015) suggested that isoflavones should be classified under isoflavonoids instead of flavonoids. Flavonoids are further classified into six subclasses, with specific compounds listed under each. For example, phloretin and arbutin are grouped under the chalcone subclass; apigenin and tangeretin under flavones; quercetin and rutin under flavonols; genistein and daidzein under isoflavonoids; and cyanidin and malvidin under anthocyanins (Panche et al., 2016). Researchers have long been interested in developing flavonoids as therapeutic agents, leading to numerous studies aimed at increasing their use in clinical trials. Flavonoids have been identified to possess various beneficial properties, including neuroprotective, anti-inflammatory, analgesic, anti-cancer, anti-microbial, antiviral, and antiparasitic effects (Ullah et al., 2020). Due to their antiparasitic activities, extensive research has been carried out to explore flavonoids as potential new antiparasitic drug candidates.

Flavonols

Flavonols are a subclass of flavonoids distinguished by the presence of a hydroxyl group at the C3 position and a double bond between C2 and C3 in the heterocyclic ring (ring C), which contributes to their structural stability and biological activity. These compounds are commonly glycosylated, appearing as mono-, di-, or triglycosides, primarily at the C3 position, which influences their solubility, bioavailability, and physiological effects. Rutinosides, which are flavonol glycosides with at least two sugar moieties, are commonly observed. Flavonols are widely distributed in plant-based foods, with significant variations in their concentrations. Foods such as berries, broccoli, onions, apples, and tomatoes are known to contain high levels of flavonols (Murkovic, 2015). The most commonly studied flavonols include myricetin, kaempferol, and quercetin, along with their derivatives. These compounds have demonstrated various biological activities, including antitumor, antiparasitic, antibacterial, and antifungal effects, as confirmed by numerous research studies (Argüello-García et al., 2020; Martins et al., 2019; Periferakis et al., 2022; da Silva, 2021).

MATERIALS AND METHODS

This review was conducted in alignment with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure methodological rigor and transparency. All checklist items were strictly adhered to according to the PRISMA 2020 framework, guaranteeing consistency and completeness in reporting (Page et al., 2021).

Search strategy

The systematic review was conducted using four major academic databases: ProQuest, Web of Science, Science Direct, and PubMed. The primary search terms employed were “Flavonols AND antiparasitic” and “Flavonoids AND antiparasitic”, applied specifically to the [Title/Abstract] fields. Additionally, to ensure relevance and accessibility, the search was limited to full-text open-access articles published between 2013 and 2023.

Eligibility criteria

Irrelevant data were systematically excluded by screening academic paper titles and abstracts. Inclusion criteria for this review were defined through a detailed evaluation of relevant studies. Inclusion Criteria: Studies were selected based on the following parameters: 1. Articles published in English or Malay; 2. Research discussing the antiparasitic effects of flavonoids; 3. Studies with full-text access; 4. Papers addressing the biology of parasites; 5. Publications from 2013 to 2023; 5. Data sourced from PubMed, ScienceDirect, ProQuest, and Web of Science. Exclusion Criteria: The following studies were excluded: 1. Articles published in languages other than English or Malay; 2. Research with uncertain methods, data, or outcomes; 3. Letters, conference papers, posters, editorials, and review articles; 4. Studies from disputed or predatory journals.

Risk of bias assessment

The Quality Assessment with Diverse Studies (QuADS) criteria were applied to systematically evaluate the methodological rigor of the studies included in the final data synthesis. This framework ensured a comprehensive, standardized assessment, allowing for consistency in identifying strengths and limitations across diverse research designs (Harrison et al., 2021). This 13-criteria instrument assesses the quality of various research designs, including mixed-methods, quantitative, and qualitative studies. Each criterion is scored from 0 (no mention) to 3 (full information), with a maximum possible score of 39.

Each study was assigned a QuADS score, which was then used to create an overall quality evaluation by summing all the item scores and dividing the result by the highest possible score. Studies were categorized based on their scores as follows: less than 50% (poor methodological quality), between 50% and 70% (moderate methodological quality), and more than 70% (high methodological quality) (Medlinskiene et al., 2021).

Study selection

The articles were selected based on their relevance to the antiparasitic effects of flavonoid compounds, including studies on flavonoid biosynthesis, molecular modification to enhance antiparasitic activity, parasite biology, and the epidemiology of parasitic diseases.

Data collection process

Mendeley Reference Manager was used as the primary storage for all results obtained from the search strategy, as it provides a folder for managing and checking for duplicate articles. Redundant research was removed from this folder. The data were then tabulated using Microsoft Word and organized into columns for number, name of the compounds, source of the compounds, name of the tested parasites, study design, results of the selected research, and their references.

RESULTS

Data collection was conducted between October and December 2023, focusing on academic papers published in English and Malay. The screening process was carried out by the supervisor and co-supervisors, with any discrepancies resolved by the first author. From a total of 1,629 papers identified through a systematic search of digital databases, 180 met the eligibility criteria. Additionally, four articles were retrieved from the reference lists of included studies, one of which was incorporated into the final review.

This systematic review ultimately included 42 studies after applying exclusion criteria. Articles published in languages other than English and Malay, studies with unclear methods, data, or outcomes, as well as letters, conference papers, posters, editorials, and publications from disputed or predatory journals were omitted. The results have been summarized in the PRISMA 2020 flow diagram (Figure 2).

Quality Assessment

As mentioned earlier, the studies were evaluated using the QuADS tool to assess their quality and risk of bias. The methodological quality of the examined research ranged from 54% to 82%. Specifically, 18 studies were classified as having high-quality methodologies, with scores ranging from 72% to 82%. Conversely, 24 studies displayed moderate-quality methodologies, earning scores between 54% and 69%. No studies were found to have low scores. The table of risk of bias assessment is provided in the supplementary document (Appendix 1).

Antiparasitic activity of flavonols

Table 1 summarizes the findings on the antiparasitic activity of flavonol compounds. The antiparasitic activity of flavonol derivatives is compiled in Table S1 (Supplementary file- Appendix 2), and the antiparasitic activity of plant extracts containing flavonols as major compounds is discussed in Table S2 (Supplementary file- Appendix 2).

Mechanism of action of flavonols as antiparasitic agent

Several studies have been conducted to elucidate the mechanisms by which flavonols contribute to antiparasitic properties. Conserva et al. (2021) observed a persistent increase in intracellular parasite Ca^{2+} levels. The death of *T. cruzi* might be due to a Ca^{2+} imbalance triggered by compound **21**. Following a two-hour incubation period, the trypomastigotes exhibited an increase in mitochondrial membrane potential, which was followed by depolarization after four hours. Additionally, ATP levels were reduced after four hours. Furthermore, compound **1** has been documented to demonstrate several methods of inhibiting parasites, as supported by numerous research findings. Compound **1** (Figure 3) was shown to interfere with the mitochondrial membrane potential of parasites, leading to impaired mitochondrial function (Abugri et al., 2023; Larit et al., 2021; Yang et al., 2020).

Furthermore, it has been demonstrated that quercetin induces an increase in the formation of reactive oxygen species (ROS) within parasites (Abugri et al., 2023; Cataneo et al., 2019), primarily causing either necrosis or apoptosis. Compound 1 has also been reported to stimulate the activation of nuclear factor erythroid 2-related factor (Nrf2), functioning as an antioxidant. When administered to L. braziliensis-infected macrophages, it was found that Nrf2 and heme oxygenase 1 (HO-1) expression levels increased. Additionally, flavonols have been verified to repress parasitic enzymes, thereby enhancing their antiparasitic activity. Yang et al. (2020) and Larit et al. (2021) demonstrated that compounds **1** and **3** can inhibit crucial parasite enzymes, such as acetylcholinesterase, DNA topoisomerase, kinase, and heat-shock protein (HSP), specifically the *T. brucei* Hexokinase 1 (TbHK1) enzymes.

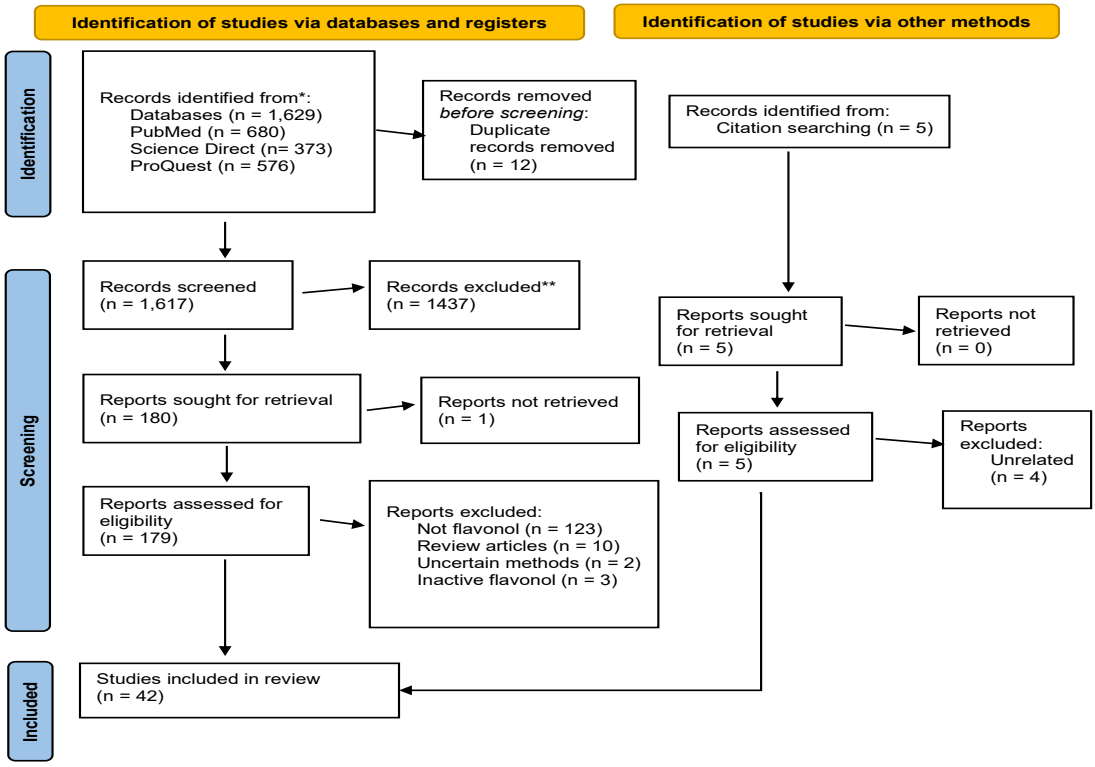

Figure 2: PRISMA 2020 flow diagram summarising systematic search and study selection

Compound **4** inhibits the functioning of arginase (ARG), decreases glutathione (GSH) levels, and reduces nitric oxide (NO) production. These effects collectively impede the proliferation of promastigotes (Adinehbeigi et al., 2017). Mehwish et al. (2021) verified that trypanothione reductase (Try-R) and trypanothione synthetase (Try-S) enzymes were inhibited in *L. donovani* after compounds **1** and **27** were applied for 24 hours. Additionally, it has been shown that both compounds can directly attach to DNA by intercalation, causing damage to double-stranded DNA at its original location. Transmission electron microscopy (TEM) analysis demonstrated that both compounds induced significant changes in the ultrastructure of parasite cells. These changes included nuclear condensation, deformation of the flagellar pocket, disruption of the mitochondria-kinetoplast complex, and an increase in lipid droplets. These alterations ultimately resulted in the mortality of *Leishmania* parasites.

Additionally, compound **8** triggered significant mitochondrial morphological changes, including the formation of cytoplasmic lipid bodies, enlarged and swollen mitochondria compared to the untreated control, and an increase in plasma membrane blebs (surface blebbing) in *L. amaz*/tc3 promastigotes. Moreover, this compound enhanced the production of Th1 cytokines in infected cultured macrophages, surpassing levels observed in infected but non-stimulated controls. Notably, cells treated with compound 8 exhibited a higher production of IL-12 p70 (García-Bustos et al., 2021).

Additionally, *Leishmania* species contain arginase, the initial enzyme in the polyamine (PA) pathway. Inhibiting this enzyme can enhance oxidative stress and facilitate infection management. Compound **4** has demonstrated strong inhibitory activity on arginase. This inhibitory activity is closely linked to the presence or absence of a sugar moiety at position 3 in the flavonoid molecule. Noncompetitive inhibition was identified for the C-glucoside, while mixed inhibition was observed for the O-glucoside. These hydrogen bonds function as 'molecular anchors' to assist the binding of molecules to the enzyme's active site (Manjolin et al., 2013).

Nwodo et al. (2015) explained the inhibitory mechanism of compound 7, which appears to be related to the extent of methylation of the hydroxyl groups and its effectiveness against trypanosomes. The increased lipophilicity of the compound enhances its permeability through the parasite membranes. Additionally, Gupta et al. (2022) determined that the mechanism through which DHDM-Zn inhibits *L. donovani* is attributed to cell cycle arrest at the G1/S checkpoint. This arrest prolongs the G1 phase and increases the cell population, preventing the targeted parasite from initiating nuclear division due to DNA arrest.

Table 1: Antiparasitic activity of flavonols

Compounds	Source	Parasites	Study design	Results	Reference
Quercetin **(1)**	Santa Cruz Bio-technology Inc.	*T. gondii*	*In vitro*	IC_{50} 0.50 µM	(Abugri et al., 2023)
	Acros (Fair Lawn, NJ, USA)	*L. braziliensis*		48 and 70 µM showed leishmanicidal activity	(Cataneo et al., 2019)
	Sigma Aldrich	*E. histolytica*, *T. vaginalis*		IC_{50} 44.48 µg/mL (*E. histolytica*) 21.17 µg/mL (*T. vaginalis*)	(Elizondo-Luévano et al., 2021)
	Pelliciera rhizophorae	*L. donovani*, *P. falciparum*, *T. cruzi*	*In vitro* *In silico*	IC_{50} 12.6 ± 0.2 µM (*L. donovani*), 9.7 ± 0.3 µM (*P. falciparum*), 13.0 ± 0.4 µM (*T. cruzi*)	(López et al., 2015)
	Hypericum afrum	*T. brucei*	*In vitro*	IC_{50} 7.52 µM, IC_{90} 9.76 µM	(Larit et al., 2021)
	Dioscorea bulbifera	*P. falciparum K1*, *P. falciparum 3D7*		IC_{50} 28.47 µM (*P. falciparum K*1), IC_{50} 50.99 µM (*P. falciparum 3D7*)	(Chaniad et al., 2021)
	Merck KGaA	*L. major*, *P. falciparum*	*In vitro*	Effective in all concentrations (100, 200 & 400 µg/ml) against *L. major*. 400 µg/ml was the most effective dose for antiplasmodial activity	(Hanif et al., 2023)
	Sigma-Aldrich	*L. donovani*		IC_{50} 84.65 µg/mL	(Mehwish et al., 2021)
	Sigma–Aldrich	*L. amazonensis*	*In vitro* *In silico*	IC_{50} 4.3 µM	(Manjolin et al., 2013)
	Persea americana	*P. berghei*	*In vivo*	Chemosuppression of parasitemia (>50%)	(Uzor et al., 2021)
Kaempferol **(2)**	*Nectandra oppositifolia*	*T. cruzi*	*In vitro*	IC_{50} 32.0 µM	(Conserva et al., 2021)
	Annona cherimola	*G. duodenalis*	*In vitro* *In silico*	Proapoptotic effect on *G. duodenalis* trophozoites	(Argüello-García et al., 2020)
	Helianthemum glomeratum	*E. histolytica*	*In vitro*	Decreased the viability of *E. histolytica* to 44.5% at concentration of 150 µM	(Levaro-Loquio et al., 2023)
	Pelliciera rhizophorae	*L. donovani*	*In vitro* *In silico*	IC_{50} 22.9 ± 0.2 µM	(López et al., 2015)
	Dioscorea bulbifera	*P. falciparum K1*, *P. falciparum 3D7*	*In vitro*	IC_{50} 62.45 µM (*P. falciparum K*1), IC_{50} > 80 µM (*P. falciparum 3D7*)	(Chaniad et al., 2021)
	Temperate Propolis	*T. brucei*, *L. mexicana*		*T. brucei* IC_{50} 24 µM (TbS427WT), IC_{50} 30.2 µM (B48), IC_{50} 28.4 µM (ISMR1), *L. mexicana* IC_{50} 414 µM (WT)	(Alotaibi et al., 2021)
	Senna surattensis	*T. b. rhodesiense*	*In vitro*	IC_{50} 10.35 ± 0.38 µM	(Dawurung et al., 2021)
	Sigma–Aldrich	*L. amazonensis*	*In vitro* *In silico*	IC_{50} 50 µM	(Manjolin et al., 2013)
Myricetin **(3)**	*Hypericum afrum*	*T. brucei*		IC_{50} 5.71 µM, IC_{90} 7.97 µM	(Larit et al., 2021)
Fisetin **(4)**	Sigma-Aldrich	*L. amazonensis*		IC_{50} 1.4 µM.	(Manjolin et al., 2013)
		L. infantum	*In vitro*	IC_{50} 0.283 µM against promastigotes and 0.102 µM against amastigotes	(Adinehbeigi et al., 2017)
Morin **(5)**		*L. amaz/tc*	*In vitro* *In vivo*	IC_{50} 122.4 ± 2.55 µM	(García-Bustos et al., 2021)
Penduletin **(6)**	*Vitex simplicifolia*	*T. b. rhodesiense*	*In vitro*	IC_{50} 13.8 µg/ml	(Nwodo et al., 2015)
Artemetin **(7)**				IC_{50} 4.7 µg/ml	
Galangin **(8)**	Temperate Propolis	*T. brucei*, *L. mexicana*		*T. brucei* IC_{50} 28.2 µM (TbS427WT), IC_{50} 32.2 µM (B48) IC_{50} 26.3 µM (ISMR1) *L. mexicana* IC_{50} 20.2 µM (WT), IC_{50} 54.4 µM (C12Rx)	(Alotaibi et al., 2021)
	Sigma-Aldrich	*L. amaz/tc3*	*In vitro* *In vivo*	IC_{50} 20.59 ± 4.47 µM	(García-Bustos et al., 2021)
		L. amazonensis	*In vitro* *In silico*	IC_{50} 100 µM	(Manjolin et al., 2013)
6,5'-dihydroxyflavonol **(9)**	Sigma-Aldrich	*T. brucei* pteridine reductase 1 *(Tb*PTR1*)* *L. major* pteridine reductase *1 (Lm*PTR1*)*	*In vitro* *In silico*	IC_{50} 4.3 Mm (*Tb*PTR1), IC_{50} 12.5 µM (*Lm*PTR1)	(Di Pisa et al., 2017)
6,4',5'-trihydroxyflavonol **(10)**				IC_{50} 38.0 µM (*Tb*PTR1), IC_{50} 35.0 µM (*Lm*PTR1)	

Levaro-Loquio et al. (2023) conducted an extensive analysis of the amoebicidal properties of compound 2 against *E. histolytica*. The compound stimulates excessive protein production in *E. histolytica* while suppressing the activity of enzymes such as thioredoxin reductase (TrxR), peroxiredoxin (Prx), and rubrerythrin (Rr). It also lowers

the activity of myeloperoxidase (MPO) and reduces interactions between neutrophils and *E. histolytica*. Furthermore, compound **2** causes a low release of ROS and reduces NO production in *E. histolytica*, affecting the functioning of detoxifying enzymes and interactions between the parasite and neutrophils.

The inhibitory action of flavonol glycosides has also been documented by Martín-Escolano et al. (2021). Compound **38** induced structural modifications in *Acanthamoeba* trophozoites, leading to the formation of spherical trophozoites lacking acanthopodia and containing substantial vacuoles. Upon exposure to compounds **39**, **40**, and **41**, a significant number of trophozoites detached and subsequently died. Additionally, certain trophozoites exhibited distinct structural alterations, including decreased size, absence of acanthopodia, and a more rounded shape.

Recent research suggests several molecular modifications that could enhance the antiparasitic effects of flavonols. For example, compound **21** highlights the importance of incorporating a p-coumaroyl group into the rhamnoside moiety to boost antiparasitic activity and reduce mammalian toxicity compared to kaempferol (Conserva et al., 2021). Abdeyazdan et al. (2022) demonstrated that the increased lipophilicity of compound **24**, relative to amphotericin B and antimony complexes, led to superior anti-promastigote activity against *L. major*. Although flavonol antimony complexes showed limited effectiveness against promastigotes, they exhibited stronger anti-amastigote effects compared to meglumine antimonate, with IC_{50} values ranging from 0.5 to 15 µM.

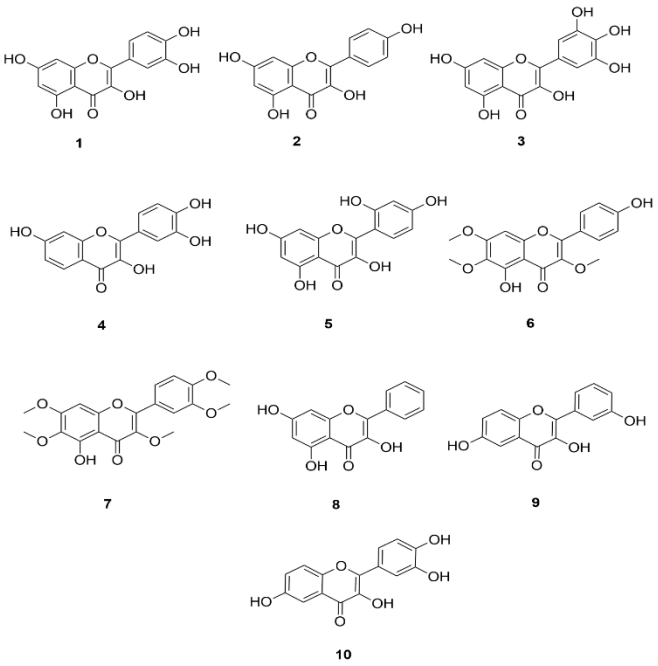

Figure 3: Chemical structure of antiparasitic flavonols (refer Table 1).

Molecular modification of flavonols to increase antiparasitic activity

These findings suggest that modifications to the molecular structure or the introduction of specific functional groups can markedly enhance the antiparasitic efficacy of flavonols. To understand the superior IC_{50} and IC_{90} values of compound **3** compared to compound **1**, Larit et al. (2021) conducted a molecular docking study. Compound **3** had a docking score of -8.31 kcal/mol, while compound **1** scored -6.62 kcal/mol. The additional hydroxyl group on compound **3** did not result in significant new interactions with neighbouring amino acids. However, some chemical bonds were disrupted, likely due to the rearrangement of interacting functional groups to accommodate the extra hydroxyl group within the binding site. During molecular dynamics (MD) simulations, myricetin maintained a stable position in the binding pocket, with a root mean square deviation (RMSD) of approximately 3.0 Å. In contrast, compound 1 had a much higher RMSD value of around 15.0 Å.

A study revealed that compound **1**, a flavonol known for its potent antimalarial properties against *Plasmodium falciparum*, is more effective in inhibition compared to quercetin glycosides, which showed lesser effects. Compound **1**, with five hydroxyl groups at positions 3, 5, 7, 3', and 4', exhibited significant interactions with *Plasmodium falciparum* lactate dehydrogenase (PfLDH), similar to those of artesunate. The binding configurations of this compound differ from those of other flavonoids, forming a hydrogen bond with ASP53 through direct interaction. Its strong activity may be attributed to the substantial number of hydrogen bonds and the variability in binding patterns (Chaniad et al., 2021).

Nwodo et al. (2015) suggested that methylation of the hydroxyl groups might enhance the trypanocidal effect of compound **7**, supporting its antiparasitic properties. The concomitant increase in lipophilicity improves the compound's ability to penetrate parasite membranes, explaining the observed effect. The presence of a methoxy group at position C-3 may be responsible for the activity of active molecules in this context. Additionally, the absence of an OH group in ring B might contribute to the compound's effect.

Furthermore, the interaction between compound **4** and the *Leishmania amazonensis* arginase enzyme (ARG-L) is strengthened through an inversion of the interaction, facilitating hydrophobic interactions between the flavone group of compound **4** and His154 and His139. The presence of the catechol group is crucial for inhibitory action, as its absence results in minimal inhibition. The

hydroxyl group at position 3 plays a crucial role in the inhibitory action of arginase, whereas the hydroxyl group at position 5 has minimal impact. These compounds bind to the enzyme's active site via hydrogen bonding, serving as molecular anchors that stabilize interactions. Manjolin et al. (2013) reported that ARG-L inhibition is significantly enhanced when the phenyl group is hydroxylated at positions 3, 5, and 7, suggesting that specific hydroxylation patterns influence binding efficiency and enzymatic suppression.

DISCUSSION

Antiparasitic activity of flavonols

Flavonols have demonstrated antiparasitic activity against a broad spectrum of protozoan species. Notably, several studies have reported that specific flavonols possess the ability to inhibit multiple protozoan types, highlighting their potential as versatile antiparasitic agents. A study by Abugri et al. (2023) confirmed the potent antitoxoplasma activity of compound **1,** which exhibited an IC_{50} of 0.50 µM against *T. gondii*. Compound **1,** when mixed with azithromycin at a 2:1 ratio, the mixture demonstrated a synergistic effect, yielding an IC_{50} of 0.08 µM against *T. gondii,* substantially lower than the IC_{50} values of compound **1** and azithromycin (0.66 µM) alone.

Several studies have evaluated the antileishmanial effects of compound **1**. Remarkably, Cataneo et al. (2019) revealed that compound **1** exhibited leishmanicidal action at 48 and 70 µM concentrations. Both doses significantly decreased the average number of *L. braziliensis* amastigotes per macrophage. López et al. (2015) documented an IC_{50} value of 12.6 ± 0.2 µM, though Mehwish et al. (2021) discovered an IC_{50} value of 84.65 µg/mL against *L. donovani.* The latter investigation revealed a noteworthy occurrence of DNA damage, as indicated by a Total Comet Score (TCS) of 57. In addition, Hanif et al. (2023) confirmed the effectiveness of compound **1** at all tested concentrations (100, 200 and 400 µg/mL) against *L. major*. Manjolin et al. (2013) conducted a distinct *in vitro* study and found that the IC_{50} against *L. amazonensis* was 4.3 µM. The compound demonstrated inhibitory effects on *P. falciparum*, with IC_{50} 9.7, 28.47 and 50.99 µM, as reported by Chaniad et al. (2021) and López et al. (2015). According to Hanif et al. (2023) again, compound **1** achieved more than 50% chemosuppression of parasitemia against *P. berghei* in an *in vivo* study, while Uzor et al. (2021) found that 400 µg/mL was the most effective dose for antiplasmodial action. Conversely, Elizondo-Luévano et al. (2021) assessed the effectiveness of the same compound against *E. histolytica* and *T. vaginalis* and found IC_{50} 44.48 and 21.17 µg/mL, respectively. Concurrently, favourable results were obtained from studies on effectiveness against *Trypanosoma* sp. A study by López et al. (2015) reported the IC_{50} 13.0 µM against *T. cruzi* whereas Larit et al. (2021) found the IC_{50} against *T. brucei* was 7.52 µM, and the IC_{90} was 9.76 µM. Also, Dawurung et al. (2021) observed an IC_{50} 8.44 µM against *T. b. rhodesiense*.

Apart from compound **1**, compound 2 has also demonstrated a broad spectrum of antiparasitic activities. Conserva et al. (2021) reported an IC_{50} of 32.0 µM against *T. cruzi*, while Dawurung et al. (2021) found an IC_{50} of 10.35 ± 0.38 µM against *T. b. rhodesiense*. Further testing on *T. brucei* strains TbS427WT, B48, and ISMR1 revealed IC_{50} values of 24, 30.2, and 28.4 µM, respectively (Alotaibi et al., 2021). In a combined *in vitro* and *in silico* study, compound **2** exhibited a proapoptotic effect on *G. duodenalis* (Argüello-García et al., 2020). Levaro-Loquio et al. (2023) found that compound **2** showed amoebicidal activity against *E. histolytica* at a concentration of 150 µM, significantly reducing viability to 44.5%, a notable difference from the effect of metronidazole.

Compound **2** also targeted *L. donovani*, resulting in an IC_{50} of 22.9 ± 0.2 µM (López et al., 2015). Alotaibi et al. (2021) discovered antileishmanial activity against *L. mexicana* strain WT, with an IC_{50} of 414 µM, while Manjolin et al. (2013) reported a lower IC_{50} of 50 µM against *L. amazonensis*. Chaniad et al. (2021) determined IC_{50} values of 62.45 µM and >80 µM for *P. falciparum* strains K1 and 3D7, respectively. Compound **3** exhibited IC_{50} and IC_{90} values of 5.71 µM and 7.97 µM, respectively, against *T. brucei* (Larit et al., 2021). Compound **4** showed leishmanicidal activity against *L. amazonensis* with an IC_{50} of 1.4 µM (Manjolin et al., 2013) and also exhibited IC_{50} values of 0.283 µM against promastigotes and 0.102 µM against amastigotes of *L. infantum* (Adinehbeigi et al., 2017).

Compound **5** had an IC_{50} of 122.4 ± 2.55 µM against the *L. (L.) amazonensis* clone (*L. amaz/tc3*) (García-Bustos et al., 2021). Compounds **6** and **7**, extracted from *V. simplicifolia*, showed trypanocidal activity against *T. b. rhodesiense* with IC_{50} values of 13.8 µg/mL and 4.7 µg/mL, respectively (Nwodo et al., 2015). The antiparasitic properties of compound **8** have been extensively studied. Alotaibi et al. (2021) identified IC_{50} values of 28.2, 32.2, and 26.3 µM against *T. brucei* strains TbS427WT, B48, and ISMR1, respectively. The IC_{50} for inhibiting the growth of *L. mexicana* strains Leish WT and C12Rx were 20.2 and 54.4 µM, respectively. García-Bustos et al. (2021) recorded an IC_{50} of 20.59 ± 4.47 µM against *L. amaz/tc3*, while Manjolin et al. (2013) documented a higher IC_{50} of 100 µM against *L. amazonensis*.

Compounds **9** and **10** were tested against the parasite enzymes TbPTR1 and LmPTR1 by Di Pisa et al. (2017). Compound **9** had significant inhibitory effects on both enzymes, with IC_{50} values of 4.3 µM against TbPTR1 and 12.5 µM against LmPTR1. Conversely, compound **10** showed moderate inhibition with IC_{50} values of 38.0 and 35.0 µM against TbPTR1 and LmPTR1, respectively.

Antiparasitic activity of flavonol glycosides

Flavonol glycosides are a type of flavonoid compound found in various plants, particularly medicinal herbs. They consist of two primary components: a sugar molecule called glycoside, which is bound to the basic structural component of the flavonoid, the flavonol aglycone. Several studies have been conducted to determine the antiparasitic activities of flavonol glycosides. Tajuddeen et al. (2021) revealed that compound **11** (Figure S1) significantly inhibited the growth of *P. falciparum*, reducing its viability to 16.2 ± 2.2% at a dose of 50 µg/mL, while compound **12** reduced viability to 18.4 ± 2.9%. Additionally, compound **13** showed potential by reducing parasite viability to 19.1 ± 0.5%. López et al. (2015) verified the antileishmanial activity of compound **11**, with an IC_{50} of 3.4 ± 0.1 µM against *L. donovani*. Manjolin et al. (2013) reported IC_{50} values of 10 µM and 3.8 µM for compounds **11** and **12**, respectively, against *L. amazonensis*. Koagne et al. (2020) obtained an IC_{50} value of 25.1 ± 0.25 µM against the *P. falciparum* 3D7 strain.

Compound **14**, synthesized via a penta-acetylation process, exhibited leishmanicidal activity with an IC_{50} of 75.1 ± 4.7 µM against *L. amazonensis* (da Silva et al., 2021). Compound **15** was discovered by Kikowska et al. (2020) to produce a strong amoebicidal effect on *Acanthamoeba trophozoites* with an IC_{50} of 0.35 mg/mL. Chaniad et al. (2021) revealed that compounds **16** and **17** exhibited moderate antiplasmodial activity against *P. falciparum* strains K1 and 3D7. Compound **16** had IC_{50} values of 44.03 µM and 70.79 µM against K1 and 3D7, respectively, while compound **17** displayed IC_{50} values of 48.33 µM and 68.93 µM against the same strains.

Mahmoud et al. (2020) reported that compound **18** showed IC_{50} values of 4.5 µM against *L. donovani* and 7.3 µM against *P. falciparum*. Tajuddeen et al. (2022) found that compound **19** effectively reduced the viability of *P. falciparum* to 21.9 ± 1.5% at a concentration of 50 µg/mL. Koagne et al. (2020) documented an antimalarial effect of compound **20** with an IC_{50} of 19.0 ± 0.25 µM. Conserva et al. (2021) observed a more potent antiparasitic activity of compound **21** against *T. cruzi*, with an IC_{50} of 6.7 µM. Hammi et al. (2020) identified an IC_{50} of 206.40 ± 1.63 µg/mL for compound **22** (Figure S2) against *L. major.*

Tajuddeen et al. (2021) revealed that compound **23** had significant antiplasmodial activity at a dose of 50 µg/mL, reducing parasite viability to 18.1 ± 1.0%. In leishmanicidal testing on compound **24**, Abdeyazdan et al. (2022) obtained an IC_{50} of 14.93 ± 2.21 µM against *L. major*. Alotaibi et al. (2021) performed a comprehensive *in vitro* study on the effects of compounds **25** and **26** against three strains of *T. brucei* (TbS427WT, B48, and ISMR1) and two strains of *L. major* (WT and C12Rx). Compound **25** demonstrated trypanocidal activity against TbS427WT, B48, and ISMR1, with IC_{50} values of 15.2, 22.4, and 21.1 µM, respectively, and leishmanicidal action with IC_{50} values of 41.4 and 10.4 µM, respectively. Compound **26** exhibited trypanocidal abilities, with IC_{50} values of 95.2, 103, and 94.1 µM against the corresponding strains, but its leishmanicidal action was only evaluated against the WT strain, yielding an IC_{50} of 12.9 µM.

Compound **27** has been determined to exert antileishmanial effects in several studies. Hammi et al. (2020) reported an IC_{50} of 78.51 ± 1.09 µg/mL against *L. major*, while Mehwish et al. (2021) documented a slightly higher IC_{50} of 98 µg/mL against *L. donovani*. Kant et al. (2022) used a combined *in silico* and *in vivo* approach to assess the efficacy of compound **27** against *L. donovani*, finding IC_{50} values of 40.95 µM against promastigote forms and 90.09 µM against amastigote forms. García-Bustos et al. (2021) obtained a higher IC_{50} of 133 ± 8.25 µM against L. amaz/tc3 via *in vitro* and *in vivo* studies. Chepkirui et al. (2021) conducted antileishmanial research on compounds **28** and **29** against *L. donovani* antimony-sensitive and resistant strains, yielding potent IC_{50} values of 9.0 µM against the sensitive strain and 5.0 µM against the resistant strain. Compound **30** was shown to have leishmanicidal activity in a study by Gupta et al. (2022), with an IC_{50} of 63 ± 0.73 µM against *L. donovani*. Compound **31**, obtained from Saudi propolis, exhibited a minimum inhibitory concentration (MIC) of 14.7 µg/mL against *T. brucei* (Alanazi et al., 2021).

Nwodo et al. (2015) tested compounds **32–36** for their ability to inhibit *T. b. rhodesiense*, finding IC_{50} values of 10.2, 12.3, 19.4, 23.7, and 10.8 µg/mL, respectively. Compound **37**, synthesized by Olías-Molero et al. (2018), showed antileishmanial effects against *L. infantum* and *L. donovani*, with an estimated IC_{50} of 90.23 µM. Compounds 38-41 (Figure S4) were evaluated for their amoebicidal effects against *A. castellanii*, showing significant antiparasitic effects with IC_{50} values of 3.5 ± 3.0, 1.4 ± 1.2, 1.4 ± 0.4, and 2.3 ± 0.4 for compounds **38**, **39**, **40**, and **41**, respectively (Martín-escolano et al., 2021). Koagne et al. (2020) examined the antimalarial efficacy of compounds **42** and **43** against the *P. falciparum* 3D7 strain, finding strong antimalarial activity with IC_{50} values of 7.5 ± 0.25

and 6.8 ± 0.25 µM, respectively.

Antiparasitic activity of plant extracts

Plant extracts are concentrated preparations obtained from various parts of plants including leaves, flowers, stems, roots, and fruits, using specialized extraction techniques. These extracts contain a diverse array of secondary metabolites, particularly flavonols, which are known for their siginificant biological functions and therapeutic potential. Identifying specific flavonol compounds within these extracts enables researchers to better understand their mechanisms of action and explore their potential applications in promoting human health and well-being.

A study on the ethanolic extract of *E. uniflora* demonstrated significant leishmanicidal activity, with EC_{50} values of 47.0 µg/mL and 22.1 µg/mL against the promastigote and amastigote forms of *L. amazonensis*, respectively. Chemical analysis identified myricitrin (**44**) and compound **11** as the major constituents (Santos et al., 2019). Ferreira et al. (2021) further evaluated the antileishmanial properties of extracts from *M. pungens*, *A. muricata*, *N. megapotamica*, and *B. uniflora* on *L. amazonensis* and *L. braziliensis*. The *M. pungens* extract exhibited IC_{50} values of 180 µg/mL for *L. amazonensis* and 210 µg/mL for *L. braziliensis*. Similarly, the *A. muricata* extract showed IC_{50} values of 270 µg/mL and 210 µg/mL, respectively. The *N. megapotamica* extract demonstrated IC_{50} values of 200 µg/mL for *L. amazonensis* and 760 µg/mL for *L. braziliensis*. Lastly, the *B. uniflora* extract presented IC_{50} values of 220 µg/mL against *L. amazonensis* and 460 µg/mL against *L. braziliensis*.

Rama et al. (2021) developed two distinct patent-protected extracts from white grape marc, denoted as HOP and HOL. The antiparasitic investigation revealed that HOP, containing higher concentrations of compounds **2** and **27**, had superior antimalarial (IC_{50} 0.26 µg/mL) and antitoxoplasma (IC_{50} 0.57 µg/mL) effects against *P. falciparum* and *T. gondii* compared to HOL. Conversely, HOL, with a higher concentration of isoquercetin (**45**), demonstrated six times better antimalarial activity than HOP (IC_{50} 3.17 µg/mL).

In another study, the ethyl acetate extract of *C. citrinus* showed a total flavonoid content of 438.38 ± 11.73 mg RE/100 g, with IC_{50} values of 9.7 µg/mL against *T. brucei* and 13 µg/mL against *P. falciparum*. The methanol extract, with a higher total flavonoid content of 512.90 ± 11.00 mg RE/100 g, showed IC_{50} values of 8.4 µg/mL against *P. falciparum* and 6.6 µg/mL against *T. brucei* (Larayetan et al., 2019). Brito et al. (2015) evaluated the effectiveness of a hydroethanolic extract from *Z. joazeiro* in eliminating parasites such as *L. braziliensis*, *L. infantum*, and *T. cruzi*. HPLC analysis detected compounds **27** (9.72 mg/g), **12** (15.24 mg/g), **1** (21.30 mg/g), and **2** (5.17 mg/g) in the extract. The IC_{50} values were 612.06 µg/mL against *T. cruzi* and 693.67 µg/mL against *L. infantum*, but the extract was not significantly effective against *L. braziliensis* (IC_{50} > 5000 µg/mL). Bitu et al. (2017) observed effective trypanocidal activity (IC_{50} 10.6 µg/mL) against *T. cruzi*, but lower leishmanicidal efficacy (IC_{50} 236.93 µg/mL against *L. braziliensis* and 342.90 µg/mL against *L. infantum*), possibly due to the presence of compound **1** in *O. hamiltonii* leaf infusion. Kikowska et al. (2022) documented IC_{50} values of 0.25 mg/mL and 3.70 mg/mL against *Acanthamoeba* sp. strain Ac55 using *E. planum* and *E. maritimum* shoot cultures, respectively. The extract from *P. cauliflora* showed strong trypanocidal activity against *T. cruzi*, with EC_{50} values of 9.94 ± 2.25 µg/mL after two hours and 6.84 ± 2.54 µg/mL after 24 hours (Galvão et al., 2021).

The antiparasitic efficacy of pepper peel ethanolic extract (PPEE) against *T. gondii* was less potent in an *in vitro* study by Menezes et al. (2022), with the extract suppressing parasite growth at doses of 256 µg/mL and 512 µg/mL. LC-ESI-MS analysis revealed the presence of flavonol glycosides, specifically compound **11** and isorhamnetin 3-O-rhamnoside (**46**), which might be responsible for its antiparasitic properties. Using an *in vivo* method, Uzor et al. (2021) reported a chemosuppressive impact on parasitemia above 50% from the crude extract of *P. americana*. Calixto Júnior et al. (2016) provided evidence of the antiparasitic effects of *G. ulmifolia* extract, observing activity of 92.20%, 95.23%, and 61.15% against *L. braziliensis*, *L. infantum*, and *T. cruzi*, respectively.

CONCLUSION

This review highlights the broad-spectrum antiparasitic activity of various flavonol compounds against multiple protozoan species. Although some treatments have demonstrated efficacy, many exhibit limited or inconsistent results. To date, no flavonol compounds have advanced to clinical trials as antiparasitic drugs. While current findings shed light on proposed mechanisms of action and the impact of structural modifications on biological activity, further research is essential to fully elucidate their therapeutic potential and support the development of flavonols as future antiparasitic agents.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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Supplementary Material

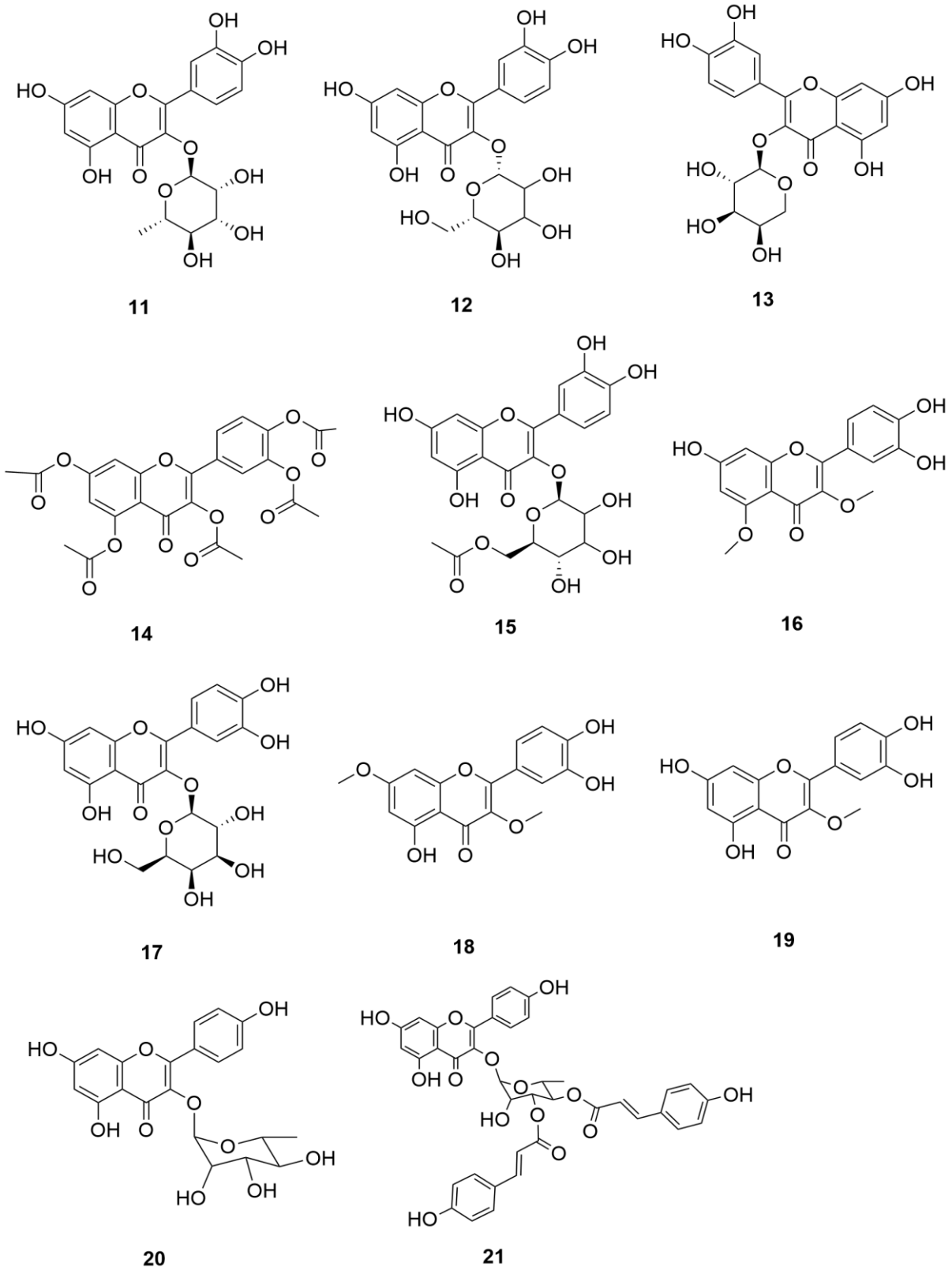
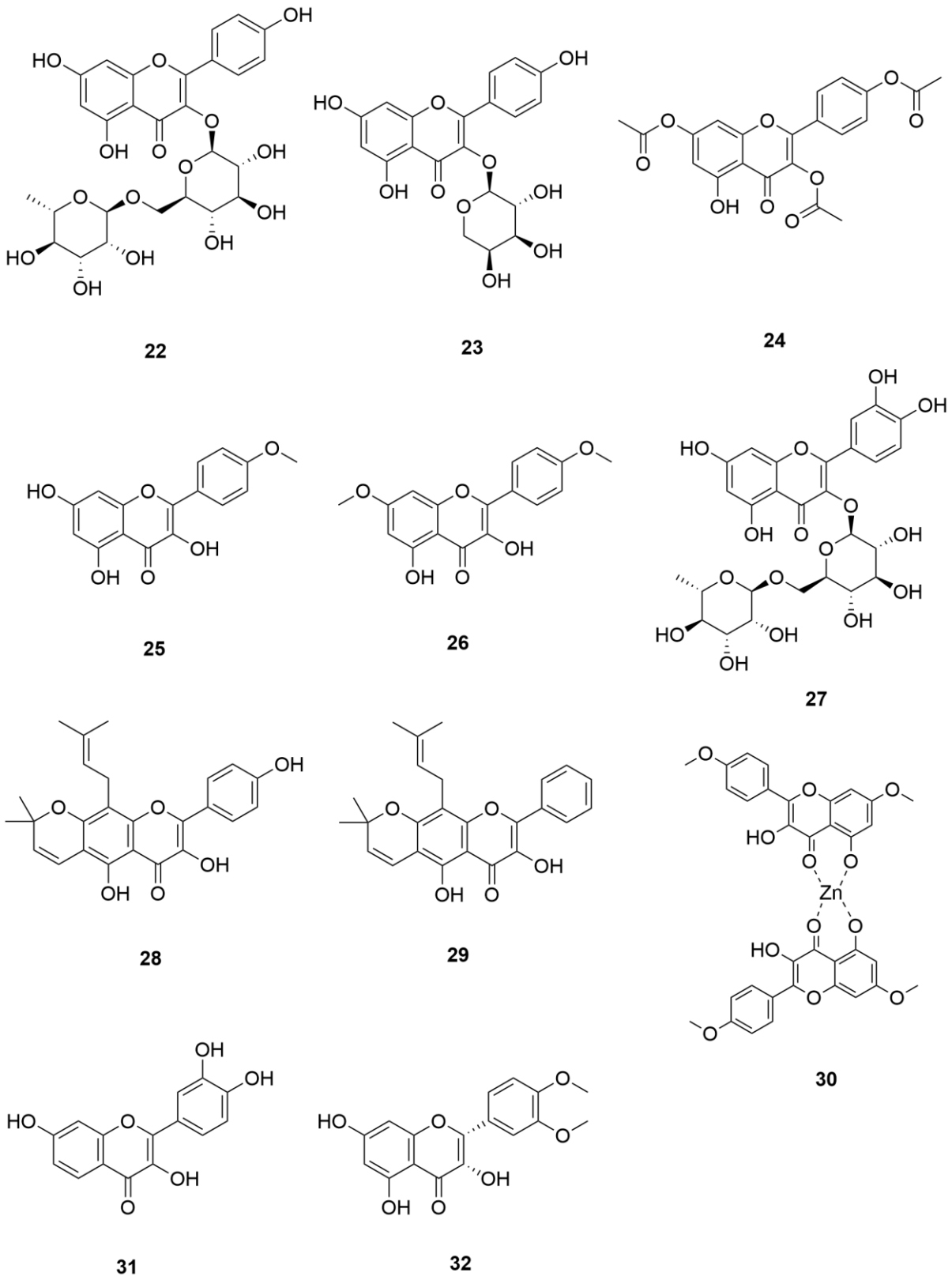


Figure S1: Chemical structure of flavonol derivatives (refer Table S1)



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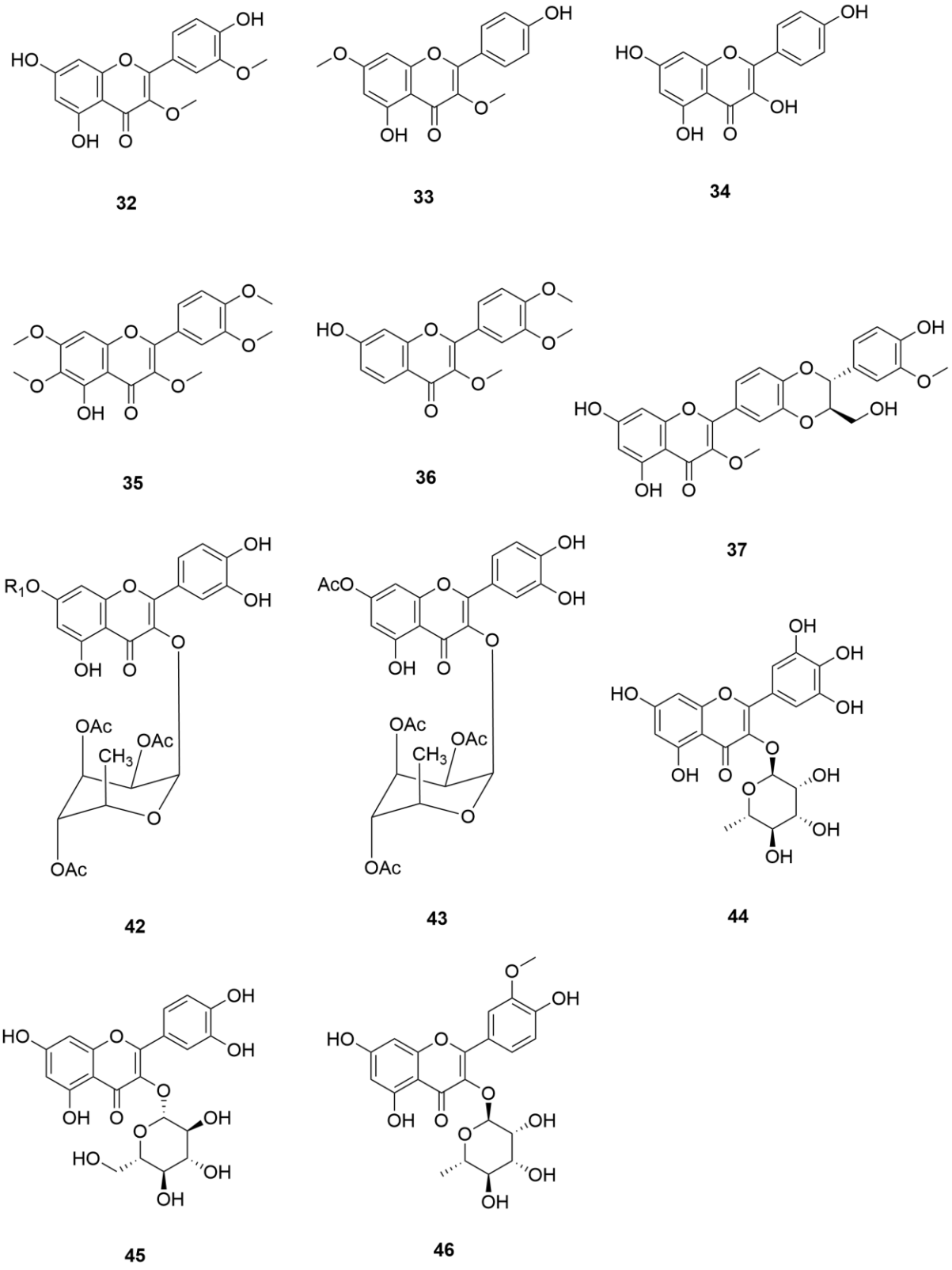
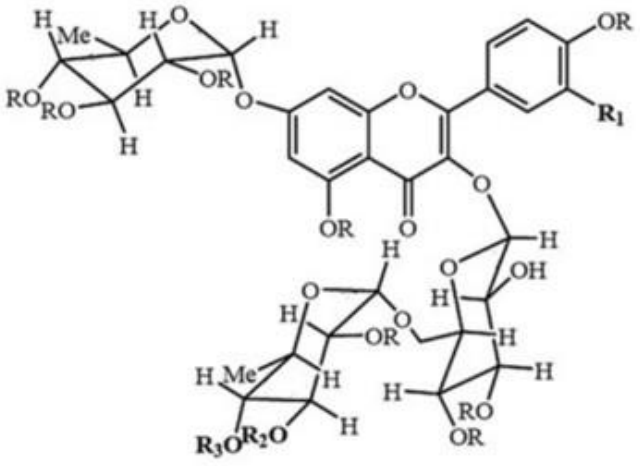
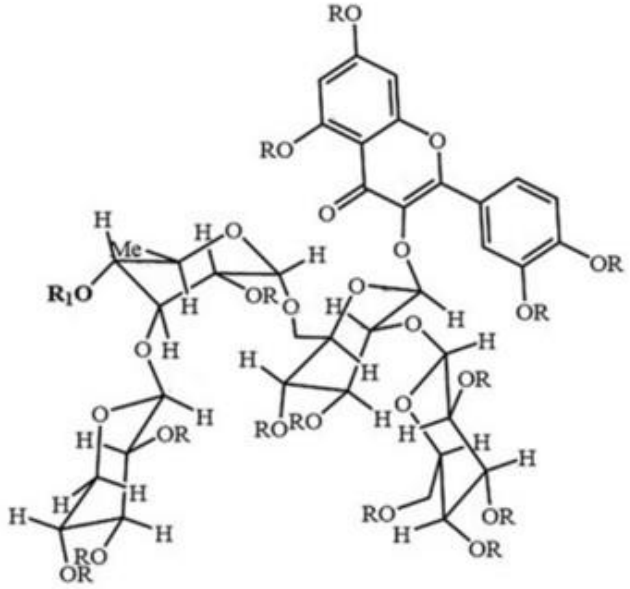


Figure S3: Chemical structure of flavonol derivatives (refer Table S1)



38: R_1 = OAc, R_2 = XylAc, R_3 = *trans-p*-coumaroylAc, R = Ac

39: R_1 = OAc, R_2 = GlcAc, R_3 = *trans-p*-coumaroylAc, R = Ac



40: R = H, R_1 = *trans-p*-caffeoyl

41: R = H, R_1 = *trans-p*-coumaroyl

Figure S4: Chemical structure of flavonol derivatives (refer Table S1). Adapted from "*In vitro* anti-*Acanthamoeba* activity of flavonoid glycosides isolated from *Delphinium gracile*, *D. staphisagria*, *Consolida oliveriana* and *Aconitum napellus*" by Martín-Escolano R, Molero Romero S, Díaz JG, Marín C, Sánchez-Moreno M, Rosales MJ, 2021, *Parasitology* 148, 1392–1400, Copyright 2021 by Cambridge University Press

Table S1: Antiparasitic activity of flavonol derivatives

Compounds	Source	Parasites	Study design	Results	Reference
Quercitrin **(11)**	*Pappea capensis*	*P. falciparum 3D7*	*In vitro*	Viability of *P. falciparum* at 50 µg/mL was 16.2 ± 2.2 percent	(Tajuddeen et al., 2021)
	Pelliciera rhizophorae	*L. donovani*	*In vitro*	IC_{50} 3.4 ± 0.1 µM	(López et al., 2015)
	Sigma–Aldrich	*L. amazonensis*	*In silico*	IC_{50} 10 µM	(Manjolin et al., 2013)
	Albizia zygia	*P. falciparum 3D7*	*In vitro*	IC_{50} 25.1 ± 0.25 µM	(Koagne et al., 2020)
Isoquercitrin **(12)**	*Pappea capensis*	*P. falciparum 3D7*		Viability of *P. falciparum* at 50 µg/mL was 18.4 ± 2.9 percent.	(Tajuddeen et al., 2021)
	Sigma–Aldrich	*L. amazonensis*	*In vitro* *In silico*	IC_{50} 3.8 µM	(Manjolin et al., 2013)
Quercetin 3-O-arabinopyranoside (guaijaverin) **(13)**	*Pappea capensis*	*P. falciparum* 3D7		Viability of *P. falciparum* at 50 µg/mL was 19.1 ± 0.5 percent	(Tajuddeen et al., 2021)
Quercetin pentaacetate **(14)**	Penta acetylation process	*L. amazonensis*	*In vitro*	IC_{50} 75.1 ± 4.7 µM	(da Silva et al., 2021)
Quercetin 3-(6-O-acetyl)-hexoside **(15)**	*Eryngium alpinum*	*Acanthamoeba trophozoites*	*In vitro* *In vivo*	IC_{50} 0.35 mg/ml	(Kikowska et al., 2020)
3,5-Dimethoxyquercetin **(16)**	*Dioscorea bulbifera*	*P. falciparum K1,* *P. falciparum 3D7*	*In vitro*	IC_{50} 44.03 µM (*P. falciparum K1*) IC_{50} 70.79 µM (*P. falciparum 3D7*)	(Chaniad et al., 2021)
Quercetin-3-O-β-D-galactopyranoside **(17)**				IC_{50}48.33 µM (*P. falciparum K1*) IC_{50} 68.93 µM (*P. falciparum 3D7*)	

Table S1: *Cont.*

Compounds	Source	Parasites	Study design	Results	Reference
Quercetin-3, 7-dimethyl ether **(18)**	*Croton gratissimus*	*P. falciparum,* *L. donovani*	*In vitro*	IC_{50} 7.3 µM against *P. falciparum* IC_{50} 4.5 µM against *L. donovani*	(Mahmoud et al., 2020)
3-O-methylquercetin **(19)**	*Vachellia xanthophloea*	*P. falciparum*		21.9 ± 1.5 percent of viability at 50 µg/mL	(Tajuddeen et al., 2022)

Kaempferol-3-O-α-L-rhamnopyranoside **(20)**	*Albizia zygia*	*P. falciparum 3D7*		IC_{50} 19.0 ± 0.25 µM	(Koagne et al., 2020)
Kaempferol-3-O-α-(3, 4-di-E-p-coumaroyl)-rhamnopyranoside **(21)**	*Nectandra oppositifolia*	*T. cruzi*		IC_{50} 6.7 µM	(Conserva et al., 2021)
Kaempferol 3-O-rutinoside **(22)**	*Moringa oleifera*	*L. major*		IC_{50} 206.40 ± 1.63 µg/mL	(Hammi et al., 2020)
Kaempferol 3-O-arabinopyranoside (juglalin) **(23)**	*Pappea capensis*	*P. falciparum 3D7*		Viability of *P. falciparum* at 50 µg/mL was 18.1 ± 1.0 percent.	(Tajuddeen et al., 2021)
Kaempferol triacetate **(24)**	Sigma–Aldrich	*L. major*	*In vitro* *In silico*	IC_{50} 14.93±2.21 µM	(Abdeyazdan et al., 2022)
4'-Methoxykaempferol **(25)**	Temperate Propolis	*T. brucei,* *L. mexicana*	*In vitro*	*T. brucei* IC_{50} 15.2 µM (TbS427WT) IC_{50} 22.4 µM (B48:) IC_{50} 21.1 µM (ISMR1) *L. mexicana* IC_{50} 41.4 µM (WT) IC_{50} 10.4 µM (C12Rx)	(Alotaibi et al., 2021)

Table S1: *Cont.*

Compounds	Source	Parasites	Study design	Results	Reference
Kaempferol 4', 7-dimethyl ether **(26)**				*T. brucei* IC_{50} 95.2 µM (TbS427WT) IC_{50} 103 µM (B48) IC_{50} 94.1 µM (ISMR1) *L. mexicana* IC_{50} 12.9 µM (WT) IC_{50} not tested (C12Rx)	
Rutin **(27)**	*Moringa oleifera*	*L. major*		IC_{50} 78.51 ± 1.09 µg/mL	(Hammi et al., 2020)
	TIPdb	*L. donovani*	*In silico* *In vivo*	IC_{50} 40.95 µM against promastigote and 90.09 µM against amastigote	(Kant et al., 2022)
	Sigma-Aldrich		*In vitro*	IC_{50} 98 µg/mL	(Mehwish et al., 2021)
		L. amaz/tc3	*In vitro*	IC_{50} 133 ± 8.25 µM	(García-Bustos et

			In vivo		al., 2021)
Dehydrolupinifolinol **(28)**	*Mundulea sericea*	*L. donovani* antimony-sensitive strain *(MHOM/IN/83/AG8)*	*In vitro*	IC_{50} 9.0 µM against the *L. donovani* antimony-sensitive strain	(Chepkirui et al., 2021)
Sericetin **(29)**		*L. donovani* antimony-resistant strain *(MHOM/IN/89/GE1)*		IC_{50} 5.0 µM against the antimony-sensitive and 38.0 µM against antimony-resistant	

Table S1: *Cont.*

Compounds	Source	Parasites	Study design	Results	Reference
Zinc derivatized 3,5-dihydroxy 4', 7-dimethoxyflavone (DHDM-Zn) **(30)**	Mixture of DHDM with zinc chloride	*L. donovani*		IC_{50} 63±0.73 µM	(Gupta et al., 2022)
Fisetindiol **(31)**	Saudi propolis	*T. brucei (S427 WT)*		MIC: 14.7 µg/ml	(Alanazi et al., 2021)
2-(5'-meth-oxyphenyl)-3,4',5,7,8-trihydroxychroman-4-one **(32)**	*Vitex simplicifolia*	*T. b. rhodesiense*		IC_{50} 10.2 µg/ml	(Nwodo et al., 2015)
2-(5'-methoxyphenyl) 4',5,7-trihydroxy-3-methoxychro-men-4-one **(33)**			*In vitro*	IC_{50} 12.3 µg/ml	
2-(4'-hydroxyphenyl)- 5-hydroxy 3,7- dimethoxy chromen-4-one **(34)**				IC_{50} 19.4 µg/ml	
2-(4- hydroxyphenyl)-3,5,7-trihydroxy chromen-4-one **(35)**				IC_{50} 23.7 µg/ml	
2-(3',4'-dimethoxyphenyl)-7-hydroxychromen-4-one (7) **(36)**				IC50 10.8 µg/ml	
Dehydroisosilybin A **(37)**	Silybin A	*L. infantum,* *L. donovani*		IC_{50} approximately 90.23 µM.	(Olías-Molero et al., 2018)
Flavonol glycoside acetate (1) **(38)**	*Delphinium gracile*	*A. castellanii*		IC_{50} 3.5 ± 3.0 µM	(Martín-escolano et al., 2021)
Flavonol glycoside acetate (2) **(39)**				IC_{50} 1.4 ± 1.2 µM	
Acylated flavonol tetraglycosides (3) **(40)**				IC_{50} 1.4 ± 0.4 µM	

Table S1: *Cont.*

Compounds	Source	Parasites	Study design	Results	Reference
Acylated flavonol tetraglycosides (4) **(41)**			*In vitro*	IC_{50} 2.3 ± 0.4 µM.	
Quercetin 2",3",4"-triacetate **(42)**	Acetylation of quercitrin	*P. falciparum* 3D7		IC_{50} 7.5 ± 0.25 µM	(Koagne et al., 2020)
Quercetin 7,2",3",4"-tetraacetate **(43)**	Acetylation of quercitrin	*P. falciparum* 3D7		IC_{50} 6.8 ± 0.25 µM	(Koagne et al., 2020)

Table S2: Antiparasitic activity of plant extracts containing flavonols

Extracts	Source	Parasites	*Study design*	Results	Reference
EtOH	*Eugenia uniflora*	*L. amazonensis*	*In vitro*	Myricitrin and quercitrin were predominant in the ethanol extract. The ethanol extract showed EC_{50} 47.0 µg/mL and 22.1 µg/ml against promastigote and amastigote form	(Santos et al., 2019)
HO_P	white grape marc	*P. falciparum,* *P. cinnamomi* (*Pc*)		Higher concentration of rutin and kaempferol was detected. Better anti toxoplasma and antiplasmodial against *P. falciparum* than HO_L	(Rama et al., 2021)
HO_L				Higher concentration of isoquercetin. 6 times better inhibition against *Pc* than HO_P.	
EtOAc	*Callistemon citrinus*	*P. falciparum,* *T. brucei*		Extract yields 438.38 ± 11.73 mg·RE/100 g of overall flavonol content. IC_{50} 9.7 µg/mL against *T. brucei* and 13 µg/mL against *P. falciparum*	(Larayetan et al., 2019)
MeOH				Extract contains 512.90 ± 11.00 mg·RE/100 g of overall flavonol content. IC_{50} 6.6 µg/mL against *T. brucei* and 8.4 µg/mL against *P. falciparum*	
EtOH	*Ziziphus joazeiro*	*L. braziliensis,* *L. infantum,* *T. cruzi*		The extract recorded IC_{50} 612.06 µg/ mL against *T. cruzi*, IC_{50} for *L. braziliensis* >5000 µg/mL and IC_{50} 693.67 µg/mL for *L. infantum.*	(Brito et al., 2015)
Leaf infusion	*O. hamiltonii*	*T. cruzi,* *L. braziliensis,* *L. infantum*		Quercetin presented in the infusion. The infusion recorded IC_{50} 10.6 µg/mL for IOH against *T. cruzi* IC_{50} 236.93 µg/mL against *L. braziliensis* and IC_{50} 342.90 µg/mL against *L. infantum*.	(Bitu et al., 2017)
Shoot culture	*E. planum*	*Acanthamoeba* sp. strain Ac55		IC_{50} 0.25 mg/ml	(Kikowska et al., 2022)
	E. maritimum			IC_{50} 3.70 mg/ml	

Table S2: *Cont.*

Extracts	Source	Parasites	*Study design*	Results	Reference
EtOH	*Myrcianthes pungens*	*L. amazonensis, L. braziliensis*	*In vitro*	The plant extract recorded IC_{50} 180 µg/ml against *L. amazonensis* and 210 µg/ml against *L. braziliensis*	(Ferreira et al., 2021)
EtOH	*Annona muricata*			IC_{50} 270 µg/ml against *La* and 210 µg/ml against *L. braziliensis*	
EtOH	*Brunfelsia uniflora*			IC_{50} 220 µg/ml against *L. amazonensis* IC_{50} 460 µg/ml against *L. braziliensis*	
EtOH	*Nectandra megapotamica*			IC_{50} 200 µg/ml against *L. amazonensis* IC_{50} 760 µg/ml against *L. braziliensis*	
EtOH	*Plinia cauliflora*	*T. cruzi*		EC_{50} of the plant leaf extract at 2 hour 9.94 ± 2.25 µg/mL and at 24 hour 6.84 ± 2.54 µg/mL	(Galvão et al., 2021)
EtOH	*Capsicum chinense*	*T. gondii*		The peel ethanol extract inhibited parasite proliferation at concentration of 256 µg/mL and 512 µg/mL	(Menezes et al., 2022)
EtOH	*Persea americana*	*P. berghei*	*In vivo*	The extract recorded chemosuppression of parasitemia (>50%)	(Uzor et al., 2021)
EtOH	*Guazuma ulmifolia*	*L. braziliensis, L. infantum, T. cruzi*	*In vitro*	Antipromastigote activity against *L. braziliensis* & *L. infantum* were 92.20% and 95.23% respectively and antitrypanosoma activity was 61.15%.	(Calixto Júnior et al., 2016)

ORIGINAL ARTICLE

Ergonomic Hazard Identification, Risk Assessment, and Control in Fish Landing Operations in Kuantan, Pahang, Malaysia

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ABSTRACT

Background: The Malaysian fishing industry is worth approximately RM11.5 billion annually and employs over 153,461 workforces. Despite its significant contribution to local livelihood and national economic growth, working in this industry is considered high-risk due to the physically demanding nature of the work, heavy workload, and long working hours, which contribute to a high incidence of occupational injuries and illnesses reported globally. To date, the role of ergonomics in addressing these safety and health issues among workers on fishing vessels has been well documented. However, there is still limited data on ergonomic issues available at the fish landing jetty, particularly in Malaysia. Hence, this study aimed to identify the ergonomic hazards associated with fish landing operations and evaluate their risks and control measures at the Fisheries Development Authority of Malaysia (LKIM) Kuantan Complex, Pahang. **Methods:** A systematic Hazard Identification, Risk Assessment, and Risk Control (HIRARC) analysis of fish landing operations was conducted based on the Department of Occupational Safety and Health (DOSH) guidelines. Walk-through observation, face-to-face interviews with workers and employers, and consultations with experts were conducted to gain insights into ergonomic issues faced by the target population. **Results:** A total of 25 ergonomic hazards were identified, of which 56% were classified as high risk with high priority for intervention. The packing catch was identified as the most ergonomically hazardous task within fish landing operations, attributed to extensive lifting, pushing, and pulling of heavy loads. Although ergonomic controls were in place, they were inadequate. **Conclusion:** The findings suggest ergonomic risks are prevalent among the fish landing workers. Therefore, a task-specific ergonomic risk assessment is necessary before improving control measures.

INTRODUCTION

The fishing industry is complex and highly diverse, encompassing small-scale traditional to large-scale commercial fishing operations. Similarly, the workforce is equally varied, which includes artisanal and commercial fishers, fish processing and fish landing workers, and boat or fishing vessel owners. Despite its significant contribution to local livelihood and national economic growth of many countries, working in this industry is considered high-risk. It is widely recognised as one of the most hazardous sectors, contributing to a high incidence of occupational injuries and illnesses reported globally (Frantzeskou et al., 2016; Eckert et al., 2018; Olapade et al., 2021; Barrow et al., 2022; Shrestha et al., 2022; Halder et al., 2024; Venugopal et al., 2024).

Previous studies have reported that fisheries workers are exposed to various types of hazards, such as slips, trips, and falls on wet and slippery surfaces, which can lead to common injuries, including sprains, strains, bruises, fractures, cuts, and lacerations (Zytoon & Basahel, 2017). Other than physical hazards, the workers are also exposed to ergonomic hazards due to the physically demanding nature of the work, heavy workload, and long working hours (Falcão et al., 2015; Berg-Beckhoff et al., 2016). Fatigue, sleep disorders and work-related musculoskeletal disorders (WMSDs) are some of the outcomes from prolonged work under unfavourable ergonomic settings (Dabholkar et al., 2014; Laraqui et al., 2022; Eckert et al., 2018; Olapade et al., 2021; Laraqui et al., 2022; Fulmer et al., 2017; Mohammed Emran et al., 2023; Halder et al., 2024).

An ergonomic hazard is any workplace condition that can cause harm to the musculoskeletal system. Ergonomic risk refers to the likelihood that exposure to such hazards will result in injury, depending on the intensity, frequency, and duration of exposure (DOSH, 2017; Centers for Disease Control and Prevention, 2024). Several ergonomic risk factors (ERFs) are widely recognised as contributors to WMSDs, including awkward and static postures, forceful exertions, repetitive movements, and vibration. The presence of multiple risk factors simultaneously can

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increase the probability and severity of injury (DOSH, 2017; Centers for Disease Control and Prevention, 2024). For instance, among traditional fishermen, professional fishers, and crew vessels, it has been determined that the main factors contributing to the high prevalence of WMSD are monotonous work operations, repetitive tasks, excessive force, and poor ergonomic postures (Fulmer et al., 2017; Sandsund et al., 2019; Emran et al., 2023).

To date, the role of ergonomics in addressing these safety and health issues among workers on fishing vessels has been well documented. However, there is still limited data on ergonomic issues available at the fish landing jetty, particularly in Malaysia. Considering the significant contribution of the fishing industry to job opportunities, the national economy, and food security, occupational safety and health issues are a growing concern that warrants urgent attention and targeted interventions. Hence, this study aims to identify the ergonomic hazards associated with fish landing operations and evaluate their risks and control measures at the LKIM Kuantan Complex, Pahang.

MATERIALS AND METHODS

Study Design

A semi-quantitative research design was employed, incorporating a walk-through risk assessment and supplementary interviews to contextualize findings. This study has received ethical approval from the Kulliyyah Postgraduate and Research Committee (KAHS 45/24) and IIUM Research Ethics Committee (IREC) (IREC 2024-196).

Study Area and Population

This study was conducted at the LKIM Kuantan Complex in Pahang, Malaysia, which serves as a primary landing site for commercial fishing vessels around Kuantan. Approximately 400workers, including fishermen, jetty workers, and fishing vessel owners, were involved in the fish landing operations at this jetty.

Instrumentation and Assessors

The HIRARC followed the Guidelines for Hazard Identification, Risk Assessment, and Risk Control (2008) established by the Department of Occupational Safety and Health (DOSH), Malaysia. The DOSH HIRARC form was adopted with minor modifications. Two trained assessors conducted the HIRARC, following guidance from supervisors and a HIRARC-trained trainer, who had also observed the job tasks on site. A pilot study was conducted to ensure the reliability of the risk rating between assessors prior to commencing the primary study.

Data Collection and Analysis

Step 1: Classification of job task

A job task was defined as a specific activity carried out by fish landing jetty workers, starting from the arrival until the departure of the fishing vessels. Through the walkthrough observation, all main and sub-tasks of the jetty operations were recorded. Additional information about the tasks was obtained through direct interviews with the workers. The recorded sub-tasks were then classified based on phases in the work process and the regularity of job tasks (i.e. routine, non-routine, and ad hoc).

Step 2: Hazards identification

For each routine sub-task, all ergonomic hazards that could pose risks to the safety and health of fish landing workers were systematically identified through site observations, photographs, and field notes. Additional explanations and clarification were obtained through face-to-face interviews with employers and workers during on-site inspections to ensure a comprehensive understanding of these hazards.

Step 3: Risk assessment

For each hazard, ergonomic exposures (i.e. awkward postures, forceful exertions, repetitive motions, static/sustained postures, and vibration) and their potential injuries were identified. Risk levels were determined based on: (1) Likelihood of a hazardous exposure, and (2) Severity of potential health impacts from exposure. The relative risk (R) scores were then calculated by multiplying the “Likelihood” (L) and “Severity” (S) indexes. A risk matrix was used to estimate the outcome risk level and to determine the appropriate action plan (Figure 1). In this matrix, green indicates a non-significant risk with no priority, yellow indicates a significant risk with medium priority, and red represents a significant risk with high priority for intervention.

Step 4: Risk controls

The existing controls for each identified hazard were recorded, and their efficiencies were evaluated based on previous experience, consultations with experts, and insights from relevant literature. Recommended controls were suggested according to the hierarchy of controls.

Likelihood / Severity	1 (Negligible)	2 (Minor)	3 (Major)	4 (Fatality/Catastrophic)
4 (Very likely)	4	8	12	16
3 (Likely)	3	6	9	12
2 (Unlikely)	2	4	6	8
1 (Highly unlikely)	1	2	3	4

Figure 1: Risk matrix

Statistical Analysis

Inter-rater reliability for pilot study risk ratings was assessed using Cohen's kappa coefficient in SPSS version 29. The analysis followed McHugh's (2012) benchmarks, with a Cohen's kappa (κ) value of 0.80 or above considered the acceptable inter-rater reliability. For categorical data, descriptive analysis was performed to summarize ergonomic risk levels across fish landing tasks.

RESULTS

Inter-Rater Reliability Analysis

The pilot study demonstrated strong inter-rater reliability (Cohen's κ = 0.87). According to McHugh (2012), this value indicated *'almost perfect'* agreement, confirming high reliability and consistency of the assessment methodology for the subsequent analyses.

Description of Main and Sub-Tasks

Fish landing operations at the LKIM Kuantan Complex in Pahang were classified into five main tasks, each comprising several sub-tasks (Figure 2). The operation commenced with the transfer of catches from the vessel to the jetty, involving four sub-tasks. This was followed by the sorting of catches, which comprised three sub-tasks, and subsequently, the weighing procedure, which consisted of four sub-tasks. Once weighing was completed, the operation proceeded to the packing process, encompassing nine sub-tasks, the highest number among all stages. The final stage of the operation was the transportation of catches from the packing to the distribution area, involving five sub-tasks.

Relative Risk Level Across Main Tasks

Overall, a total of 25 hazards related to ergonomic risk were identified (Figure 3). Of these, 56% (n = 14) were categorised as high risk and 44% (n = 11) as medium risk. Across the identified main tasks, packing catch was reported as the most hazardous during fish landing operations, accounting for the highest percentage of ergonomic hazards with high R (n = 5, 20%), which requires high priority for intervention. This was followed by sorting and weighing tasks. In contrast, transferring and transporting catches had a higher number of medium (n = 3, 12%) than high (transferring: n = 1, 4%; transporting: n = 2, 8%) R hazards with medium priority for intervention.

Figure 2: The flow of main tasks of the fish landing operations at LKIM Kuantan Complex

Further details of the HIRARC results for each main task are presented in the subsequent sections.

Task 1 - Transferring catches

Four hazards were identified during the transfer of catches from the fishing vessel to the jetty (Table 1). Controlling the rope to transfer the baskets onto the jetty posed the highest relative risk (R = 9) despite using a power-assisted manual hoist. This is because this task involved repetitive pulling of the hoist rope in awkward postures for at least two hours cumulatively. Prolonged and repeated forceful exertion increases the risk of WMSDs, particularly affecting the back, shoulders, arms, and wrists. To mitigate this, a manual rope should be replaced with a mechanical winch to eliminate risk exposure.

Task 2 - Sorting catches

The sorting catches had the fewest identified hazards (n = 3, 12%) compared to other main tasks (Figure 3). Despite the low number of hazards, this task presented high ergonomic risks (R = 9) with high priority for intervention due to the inadequacy of the existing controls (Table 2). For instance, using a rope as an extended handle can minimise excessive bending when transferring heavy baskets to the sorting table. However, pulling the baskets, especially those without wheels, requires backward arm extension and high-forceful exertion, increasing the physical strain compared to pushing. In addition, the absence of mechanical aids caused the workers to manually lift baskets exceeding 60 kg from the floor to the shoulder-height sorting table. Other than engineering controls, proper lifting/pushing techniques, task rotation, and breaks during the sorting catches may reduce physical strain and fatigue among the workers.

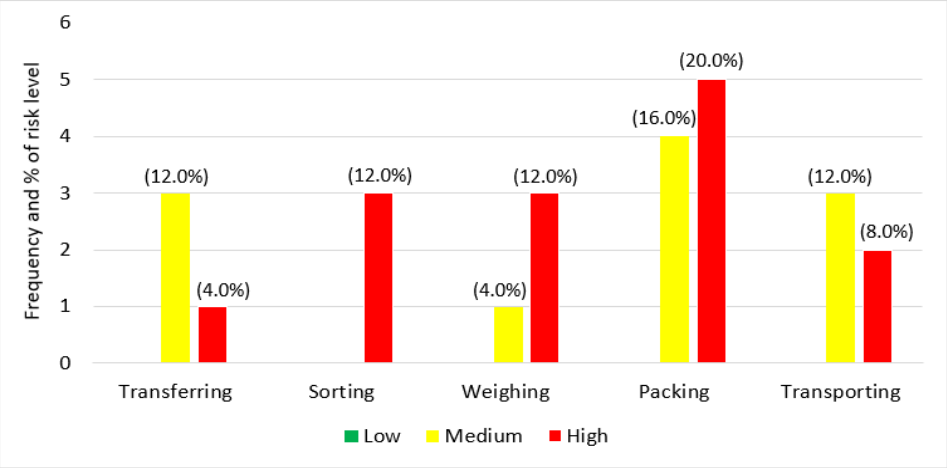

Figure 3: Overall relative risk across tasks at the LKIM Kuantan Complex

Table 1: HIRARC of transferring catches

Hazard Identification		Risk Assessment					Risk Control
Sub Task	**Ergonomic Exposure**	**Potential Health Impact**	**Existing Control**	**L**	**S**	**R**	**Recommended Control**
Transfer drums from storage room to deck	• AP • FE	Back/shoulder discomfort	Power-assisted manual hoist	3	2	6	• **Administrative:** When pushing hoist-supported drum, keep feet/shoulders aligned with push direction to prevent body twisting • **PPE:** Anti-slip gloves
Push drums to spill catches into baskets	• AP • FE • RM	Back/shoulder discomfort	Team pushing (2 workers)	3	2	6	• **Engineering:** Use hoist-assisted pouring • **Administrative:** Two-person push: face direction with straight back, coordinate with "1-2-3-push" command
Attach hoist hook to baskets	• AP	Lower back discomfort	None	3	1	3	• **Engineering:** Use an extended hook • **Administrative:** Squat (knees bent, back straight) to attach hook
Control hoist rope to transfer baskets onto jetty	• AP • FE • RM	Back/shoulder /arm/wrist strain/fatigue	Power-assisted manual hoist	3	3	9	• **Engineering:** Replace manual rope with mechanical winch • **Administrative:** Rotate operators every 15 mins

AP: Awkward Postures; FE: Forceful Exertions; RM: Repetitive Motions; L: Likelihood; S: Severity; R: Relative Risk (L×S)

Table 2: HIRARC of sorting catches

Hazard Identification		Risk Assessment					Risk Control
Sub Task	**Ergonomic Exposure**	**Potential Health Impact**	**Existing Control**	**L**	**S**	**R**	**Recommended Control**
Pull baskets from jetty to sorting area (<20 m)	• AP • FE • RM	Back/shoulder /arm/wrist strain	Rope	3	3	9	• **Engineering:** Install wheeled basket trolley with ergonomic handle • **Administrative:** Two-person push: face direction with straight back, coordinate with "1-2-3-push" command
Lift and tilt baskets from floor onto sorting table	• AP • FE • RM	Back/shoulder /arm/wrist strain	Team lifting (2 workers)	3	3	9	• **Engineering:** Use hydraulic lifter • **Administrative:** Two-person lift: squat with straight back, coordinate with "1-2-3-lift" command
Sort catches into basket while standing (>2 hrs continuously)	• AP • RM • SSP	Neck/back/ feet strain/ fatigue	None	3	3	9	• **Engineering:** Install height-adjustable sorting table • **Administrative:** Mandatory 5-min breaks every 30 mins; Task rotation hourly

AP: Awkward Postures; FE: Forceful Exertions; RM: Repetitive Motions; SSP: Static/Sustained Postures; L: Likelihood; S: Severity; R: Relative Risk (L×S)

Task 3 - Weighing catches

Table 3 summarises the HIRARC findings of the weighing catches, identifying four ergonomic hazards related to lifting, pushing, and pulling full-load baskets. Lifting baskets weighing up to 68 kg onto a weighing scale or trolley posed a high relative risk (R = 9), which was higher than arranging (pulling) the baskets (R = 6). Although both sub-tasks were performed by teams of two workers, the lifting task performed exceeded the recommended weight limit, increasing the risk of injury. To reduce risks, a wheeled basket trolley with ergonomic handles, hydraulic lifter, can promote proper team manual handling.

Table 3: HIRARC of weighing catches

Hazard Identification		Risk Assessment					Risk Control
Sub Task	**Ergonomic Exposure**	**Potential Health Impact**	**Existing Control**	**L**	**S**	**R**	**Recommended Control**
Pull baskets from sorting area to weighing area	• AP • FE • RM	Back/shoulder /arm/wrist strain	Hook	3	3	9	• **Engineering:** Install wheeled basket trolley with ergonomic handle • **Administrative:** Two-person push: face direction with straight back, coordinate with "1-2-3-push" command
Lift baskets onto weighing scale	• AP • FE • RM	Back/shoulder /arm/wrist strain	Team lifting (2 workers)	3	3	9	• **Engineering:** Use hydraulic lifter • **Administrative:** Two-person lift: squat with straight back, coordinate with "1-2-3-lift" command
Arrange baskets at designated area	• AP • FE • RM	Back/shoulder /arm/wrist discomfort	Hook, team pulling (2 workers)	3	2	6	• **Engineering:** Install wheeled basket trolley with ergonomic handle • **Administrative:** Two-person push: face direction with straight back, coordinate with "1-2-3-push" command
Lift baskets onto trolley	• AP • FE • RM	Back/shoulder /arm/wrist strain	Team lifting (2 workers)	3	3	9	• **Engineering:** Use hydraulic lifter • **Administrative:** Two-person lift: squat with straight back, coordinate with "1-2-3-lift" command

AP: Awkward Postures; FE: Forceful Exertions; RM: Repetitive Motions; L: Likelihood; S: Severity; R: Relative Risk (L×S)

Task 4 - Packing catches

Packing catches recorded the highest number of ergonomic hazards across various sub-tasks analysed (Table 4). Over half of the hazards posed high ergonomic risks (R = 9), indicating this task is complex and labour-intensive. Like other main tasks, packing catches workers posed ergonomic risks such as prolonged awkward postures, excessive forceful exertions, and repetitive lifting. These risks were more substantial, as the packing

workers must manually lift and lower full-loaded iceboxes weighing up to 140 kg. Using a forklift reduces the relative risk of transferring iceboxes from the shredded ice collecting area to the packing area (R = 3). However, it potentially introduces whole-body vibration, possibly contributing to WMSDs if not correctly managed. In addition, considering the weight, the current practice of a team lifting a 140 kg icebox, is unsafe and must be prohibited to protect workers' health and safety. The use of a hydraulic lifter or forklift, along with proper training, is strongly recommended.

Table 4: HIRARC of packing catches

Hazard Identification		Risk Assessment					Risk Control
Sub Task	**Ergonomic Exposure**	**Potential Health Impact**	**Existing Control**	**L**	**S**	**R**	**Recommended Control**
Transfer baskets to packing area	• AP • FE	Back/shoulder /arm/wrist strain	Trolley	3	3	9	• **Engineering:** Maintain trolley wheels regularly • **Administrative:** Two-person push: face direction with straight back, coordinate with "1-2-3-push" command; Ensure loads within safe weight limits
Unload baskets from trolley onto floor	• AP • FE • RM	Back/shoulder /arm/wrist strain	Team lifting (2 workers)	3	3	9	• **Engineering:** Use hydraulic lifter • **Administrative:** Two-person lift: squat with straight back, coordinate with "1-2-3-lift" command; Tilt-and-slide techniques
Transfer iceboxes from ice area to packing area	• AP • FE	Back/shoulder /arm/wrist strain	Trolley	3	3	9	• **Engineering:** Use forklift • **Administrative:** Two-person push: face direction with straight back, coordinate with "1-2-3-push" command; Ensure loads within safe weight limits
Transfer iceboxes from ice area to packing area	• WBV	Back/buttocks /hips discomfort	Forklift	3	1	3	• **Administrative:** Designate smooth transport pathways; OSHA-certified forklift training
Unload iceboxes from trolley onto floor	• AP • FE • RM	Back/shoulder /arm/wrist strain	None	3	3	9	• **Engineering:** Use hydraulic lifter • **Administrative:** Prohibit manual lifting; Tilt-and-slide techniques
Prepare plastic wrappers	• AP	Back discomfort	2 workers	3	1	3	• **Administrative:** Squat with straight back to avoid bending
Fill ice/salt solution into iceboxes using bucket	• AP • FE • RM	Back/shoulder /arm/wrist discomfort	None	3	2	6	• **Administrative:** Reposition bucket at waist height, use two-handed pouring; Mandatory 5-min breaks every 30 mins
Transfer catches from baskets into iceboxes	• AP • FE • RM	Back/shoulder /arm/wrist strain	Team lifting (2 workers)	3	3	9	• **Engineering:** Use hydraulic lifter • **Administrative:** Two-person lift: squat with straight back, coordinate with "1-2-3-lift" command
Tie plastic wrappers and cover iceboxes	• AP • RM	Back discomfort	None	3	1	3	• **Administrative:** Mandatory 5-min breaks every 30 mins

AP: Awkward Postures; FE: Forceful Exertions; RM: Repetitive Motions; WBV: Whole-Body Vibration; L: Likelihood; S: Severity; R: Relative Risk (L×S)

Task 5 - Transporting catches

Five ergonomic hazards were identified during the transport of catches from the packing area to the distributing area (Table 5). Manually lifting iceboxes onto the trolley and transferring them to the truck posed significant ergonomic risks (R = 9) due to awkward postures, forceful exertions, and repetitive movements. Consistent with findings from the packing task, manual handling of fully loaded iceboxes should be considered only as a last resort, even when performed by teams. Using a hydraulic lifter or forklift is highly recommended to eliminate manual handling risks. Additional controls include minimising repetitive push/pull motions and utilising anti-slip gloves to reduce strain and secure grip.

Table 5: HIRARC of transporting catches

Hazard Identification	Risk Assessment						Risk Control
Sub Task	**Ergonomic Exposure**	**Potential Health Impact**	**Existing Control**	**L**	**S**	**R**	**Recommended Control**
Lift iceboxes onto trolley	• AP • FE • RM	Back/shoulder /arm/wrist strain	Team lifting (2 workers)	3	3	9	• **Engineering:** Use hydraulic lifter/ forklift • **Administrative:** Prohibit manual lifting
Transfer iceboxes from packing area to truck	• AP • FE	Back/shoulder /arm/wrist strain	Trolley	3	3	9	• **Engineering:** Use forklift • **Administrative:** Two-person push: face direction with straight back, coordinate with "1-2-3-push" command; Ensure loads within safe weight limits
Transfer iceboxes from packing area to truck	• WBV	Back/buttocks /hips discomfort	Forklift	3	1	3	• **Administrative:** Designate smooth transport pathways; OSHA-certified forklift training
Control hoist rope to transfer iceboxes onto truck	• AP	Shoulder/arm /wrist discomfort	Overhead hoist crane	3	1	3	• **Administrative:** Communicate clearly with crane operator via hand signals (no direct hand contact)
Arrange the iceboxes on the truck	• AP • FE • RM	Back/shoulder /arm/wrist discomfort	None	3	2	6	• **Administrative:** Two-person push: face direction with straight back, coordinate with "1-2-3-push" command; Mandatory 5-min breaks every 30 mins • **PPE:** Anti-slip gloves

AP: Awkward Postures; FE: Forceful Exertions; RM: Repetitive Motions; WBV: Whole-Body Vibration; L: Likelihood; S: Severity; R: Relative Risk (L×S)

DISCUSSION

Ergonomic Hazards and Health Impacts

The fish landing operation at the LKIM Kuantan Complex, involved five main tasks, each comprising varying number of sub-tasks, ranging from as few as three (i.e. sorting) to as many as nine (i.e. packing). This variation reflects the complexity and diversity of activities involved in each stage of the fish landing operation, highlighting the need for a task-specific assessment and targeted control strategies.

Previous HIRARC studies in Malaysia found that fishermen were highly exposed to ergonomic hazards compared to other types of hazards (i.e. physical, chemical, and biological hazards) (Saiful et al., 2020; Saadon et al., 2023). The present study further supports these findings in which most of the identified ergonomic hazards were classified as high- and medium-risk. These risks are primarily attributed to manual handling activities such as lifting, pushing, and pulling loads from the arrival to the catch distributing areas, which similarly impose extensive physical demands on fishermen in India, Norway, and Bangladesh (Dabholkar et al., 2014; Sandsund et al., 2019; Halder et al., 2024).

The present study identified packing catches as the most hazardous task in fish landing operations, with the highest percentage of identified ergonomic hazards with high relative risks. Based on the present review of the literature, this study is the first to highlight this issue in Malaysia, which can be attributed to several key factors Firstly, the packing process involves multiple labour-intensive steps, from preparing iceboxes with shredded ice to transferring fully loaded iceboxes to the distributing areas. These activities are not only physically demanding but also involve a heavy workload to complete. Based on the interviews, workers typically start work as early as 2.30 AM and finish by late morning or afternoon on a typical workday. However, during the peak season, when multiple fishing vessels land with large marine catches, workers extended their shifts until evening or even late at night. The number of iceboxes packed daily varied depending on the company/fishing vessel size and was significantly higher during peak seasons. Previous studies have reported that high work demands, long working hours, or a combination of both are well-established risk factors for increased fatigue (Dabholkar et al., 2014), musculoskeletal disorders (MSDs) (Falcão et al., 2015; Berg-Beckhoff et al., 2016; Eckert et al., 2018; Mohammed Emran et al., 2023), osteoarticular pathologies (Mansi et al., 2019), and sleep disorders (Eckert et al., 2018; Olapade et al., 2021; Laraqui et al., 2022) among the fishing industry workers.

Secondly, packing catches involves a significant number of lifting and/or lowering tasks of different types (i.e. baskets, buckets, and iceboxes) and weights (i.e. 15 – 140 kg) of containers. Similar to most of the other main tasks, lifting occurs at low working heights (i.e. between mid-lower leg

to elbow) and is often carried out by a team of two workers. Due to constrained working spaces caused by stacked iceboxes, baskets, and unattended trolleys, packing workers often lift and/or lower loads with bent and twisted body postures. Repetitive exposure to such awkward body posture during lifting and/or lowering imposes excessive strain, especially on the lower back and upper limbs, which can eventually lead to development of WMSDs among fishery workers (Dabholkar et al., 2014; Fulmer et al., 2017; Sandsund et al., 2019; Mohammed Emran et al., 2023; Patel & Ghosh, 2023; Halder et al., 2024).

In addition to body posture, the weight of the loads is a key factor contributing to the high relative risk of lifting and/or lowering activities during fish landing operations. For example, during the packing task, a full basket of catches, approximately 68 kg, is lifted from mid-lower leg to elbow height and poured into an icebox. Each packing process typically requires transferring two baskets and takes around five to ten minutes per icebox to complete. This sub-task is performed repeatedly at a frequency of two lifts every five minutes (about 24 lifts per hour) by two workers under postural constraints. Packing more than 30 iceboxes per day is common, resulting in approximately 60 heavy lifting tasks daily. This sub-task clearly exceeds safe manual lifting limits despite workers always working in pairs.

The guidelines by DOSH (2017) and the International Organization for Standardization (2021) do not specify a single weight limit for two persons in general, but they set a 25 kg limit for individual men, provided the load is lifted between knuckle and elbow height and kept close to the body. According to the Manual Handling Assessment Charts (MAC) tool, lifting a load of less than 35 kg is considered safe for two persons. Regular lifting of loads over 50 kg every five minutes (12 lifts per hour) presents a very high level of risk, requiring immediate interventions (DOSH, 2017). Furthermore, this sub-task often includes body twisting and sideways bending, further increasing musculoskeletal injuries and lower back pain (LBP). The prevalence of LBP among fishing communities is high (Müller et al., 2022; Mohammed Emran et al., 2023) and is significantly associated with age, educational status, work experience, and body mass index (BMI) (Dienye et al., 2016; Mohammed Emran et al., 2023). Back pain primarily arises from various mechanical factors, including poor postural conditions (Patrick et al., 2014; Casiano et al., 2023), which can be managed by lifting with a straight back or using a squat technique (Nolan et al., 2018, 2020).

Thirdly, pushing and/or pulling activities during packing involve various types of loads (i.e. 60 - 400 kg), methods (i.e. with or without a trolley or forklift), and distances (i.e. 1 - 100 m). These activities can sometimes be more hazardous than the pushing and/or pulling required in other main tasks due to improper techniques and excessive weight limits. For example, during the packing task, a full-loaded trolley (i.e. stacked with baskets or iceboxes) weighing over 300 kg is commonly pushed and/or pulled by a single worker over distances exceeding 20 meters in constrained spaces. These sub-tasks are carried out repeatedly to transfer catches to the packing area and refill shredded ice from the ice crusher machine.

Although the trolleys are generally well-maintained, workers often need to overextend their arms and apply excessive force to move the heavy loads, increasing the risk of LBP and upper limb strain. According to Argubi-Wollesen et al. (2017), the cart or trolley weight is the most influential factor in reducing strain during pushing and/or pulling tasks, provided the wheels are well-maintained, as poor wheel conditions create additional resistance and increased risk of musculoskeletal injuries (Zhang et al., 2021). In addition, the handle positions should ideally range between hip to shoulder height, and the task should be performed using proper pushing and/or pulling techniques (Argubi-Wollesen et al., 2017).

High ergonomic risk related to pushing and/or pulling activities is not limited to fish landing operations. During fishing activities, fishermen frequently engage in the repetitive pulling and throwing of heavy fishing nets or pots (Dabholkar et al., 2014; Frantzeskou et al., 2016; Mohammed Emran et al., 2023). Sometimes, they must maintain their hands and body posture under physically demanding conditions on the unstable platform of fishing vessels. Working in this poor ergonomic condition can increase the risk of injury and musculoskeletal disorders, particularly in the lower back, shoulders, knees, hands, and wrists (Dabholkar et al., 2014; Mohammed Emran et al., 2023).

Recommendations for Controls

In general, the present study found that various types of controls were applied during fish landing operations, including engineering controls (e.g. hoists, forklifts), administrative controls (e.g. task rotation, irregular breaks), and personal protective equipment (PPE) (e.g. gloves, boots). Nevertheless, these controls were often inadequate, with their effectiveness influenced by two main factors: (1) Type and design of the control measures, and (2) Worker involvement and behaviour.

The availability and quality of engineering controls depend strongly on company size and resources. Larger companies can invest more in mechanical aids like forklifts, eliminating ergonomic risks associated with lifting, carrying, pushing, and lowering heavy loads. In contrast, smaller companies typically lack such equipment, exposing workers to higher musculoskeletal strain. Cart handling can also be improved through the use of ergonomically designed carts with well-maintained wheels (Argubi-Wollesen et al., 2017) and workspace improvements such as lowering ramp slopes, removing obstacles, and maintaining open spaces (Zhang et al., 2021).

Worker behaviour is also crucial in controlling effectiveness. Observations and interviews revealed inconsistent use of PPE and awareness of safe handling techniques. Improper team lifting frequently leads to instability and violations of weight regulations (Visser et al., 2014). Thus, administrative interventions are necessary, particularly regular ergonomic training. (Argubi-Wollesen et al., 2017; Zhang et al., 2021), as increasing awareness through targeted safety training has been shown to significantly improve compliance with safety practices among fishery workers (Diani Laksono et al., 2025). Promoting a strong safety culture and ensuring compliance with occupational safety standards are essential to align with Sustainable Development Goal 8, which advocates for safe and secure working environments for all.

Limitations of the Study

Firstly, this study was limited to the LKIM Kuantan Complex, which may not fully represent other fish landing sites with different layouts, equipment, or operational practices.

Secondly, this study employed a modified DOSH HIRARC form that uses a 4-point Likert scale, in contrast to the 5-point scale used in the standard DOSH version. While the exact rationale behind this modification is beyond the scope of this study, a reasonable interpretation can be made based on an understanding of HIRARC principles. For **Likelihood**, the revised matrix merges the “Remote” and “Inconceivable” categories, acknowledging that all hazards carry some probability of occurrence even if highly unlikely. For **Severity**, the revised matrix emphasizes fatal and catastrophic incidents by classifying them into a single highest category. This reflects the principle that every life is invaluable, assigning even a single fatality the maximum severity level. The use of a 4-point scale, instead of the 5-point version, simplifies assessment and improve consistency, particularly in field settings. However, it may reduce sensitivity to subtle risk differences. As a result, risk levels reported in this study may appear lower than those using the standard DOSH form, and comparisons should consider this scale adjustment.

Thirdly, this study utilized HIRARC as the primary risk assessment tool to screen for potential ergonomic hazards, serving as a preliminary step for the subsequent analysis of ergonomic risk factors and controls. Nevertheless, it is worth noting that HIRARC, while widely used in Malaysia, often functions more as a checklist-based tool rather than a detailed analytical method. While effective for general hazard identification, it lacks the quantitative precision of established ergonomic tools such as the NIOSH lifting equation, RULA and REBA. This may limit its sensitivity in identifying specific biomechanical risks, particularly in manual handling tasks. Consequently, reliance solely on HIRARC may underestimate actual ergonomic risks, potentially limiting the accuracy of the findings.

CONCLUSION

In conclusion, packing catches is considered the most hazardous task in fish landing operations. This is primarily due to its labour-intensive nature, which has the highest number of identified ergonomics hazards with high relative risks. The high ergonomic risks in packing catches originate from the sub-tasks related to lifting, lowering, pushing, and pulling loads, which are frequently performed in awkward body postures and exceeding the recommended weight limit. Although ergonomic controls are in place, they are inadequate. Previous studies have reported that poor ergonomics significantly increase the likelihood of developing WMSDs among the fisheries community. Therefore, conducting an ergonomic risk assessment of this task is necessary prior to making further improvements in task design and control strategies.

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