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ENHANCING MICROBIOTA-RELATED GUT HEALTH AWARENESS ACROSS AGE GROUPS: OUTCOMES OF INTERACTIVE EDUCATIONAL ACTIVITIES AT A SCIENCE FAIR

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ABSTRACT

The human gastrointestinal tract is host to a complex community of microorganisms called gut microbiota that is crucial for maintaining health through various metabolic, immunological and protective functions. Despite their significance, public awareness of gut microbiota remains limited among children and adults. This study aimed to assess and enhance public awareness through an interactive educational session conducted during a science fair in Kuala Lumpur, Malaysia. The session was facilitated by undergraduate and postgraduate students from a medical faculty, whereby 324 participants aged five to 64 engaged in interactive activities that included informational posters and quizzes. Participants' prior knowledge and post-session outcomes including their willingness to incorporate fruits and vegetables into their daily diet to promote healthy gut microbiota were evaluated using a questionnaire. Results from the evaluation of the questionnaire found that 77.9% of the participants acknowledged increased awareness, indicating that exposure to the activities brought about a significant rise in gut microbiota awareness. Additionally, 85.3% indicated a willingness to increase their intake of fruits and vegetables in their daily meals, while 60.5% showed readiness to bring fruit for breaks at school or work. Continued efforts involving university students in community engagement programs enhance their understanding of local needs, while the involvement of academicians integrates recent research findings into the public's awareness, ensuring the sharing of scientific knowledge.

Keywords: *Gut Microbiota Awareness, Health Education, Dietary Habits, Interactive Learning, Public Science Engagement*

INTRODUCTION

The human gastrointestinal tract is home to a diverse community of microorganisms known as the gut microbiota. Over the past two decades, there has been an extensive increment in evidence of the essential roles played by these microbes in sustaining human health (Zmora et al., 2019). These microorganisms take part in several important processes, including digestion of food, synthesis of vitamins, regulation of immune responses, and prevention of pathogen colonisation. The composition of gut microbiota is usually found to be more diversified in a healthy state when compared to a disease state, from gastrointestinal disorders to anything ranging from neurological to metabolic disorders. Research shows that balanced gut microbiota through producing microbial metabolites closely ties with

improved metabolic health and reduced inflammation, further emphasising its importance (Fan & Pedersen, 2021). Regardless of the significance of gut microbiota in maintaining health and preventing disease, the public remains to be minimally aware of this among all age groups. Building healthy dietary habits early is crucial as the fostered positive attitudes towards food can carry on into adulthood (Westenhoefer, 2002).

According to the 2023 National Health and Morbidity Survey (NHMS) by the Malaysian Health Ministry (MOH), 54.4% of Malaysian adults are overweight or obese, a significant increase from 50.1% in 2019 (IPH, 2023). The common eating-out practices by Malaysians, combined with rapid modernisation along with the rising middle class and multicultural context, has resulted in poor diet quality, defined by low consumption of fruits and vegetables and frequent consumption of ultra-processed and calorie-dense foods, thus urging the need for interventions to improve overall dietary habits among the population (Ashari et al., 2022; Eng et al., 2022; Poulain et al., 2020). Furthermore, the increased prevalence of lifestyle-related diseases such as diabetes and cardiovascular disorders highlights the urgency for educational programs which target dietary habits.

Given these challenges, improving public knowledge about gut health through educational initiatives is essential. Understanding the effects of gut microbiota on health and disease can convince people to adopt better dietary habits, as diet is a pivotal determinant in maintaining and improving gut health (Snelson et al., 2021). This is especially critical for younger individuals, as early awareness can significantly shape lifelong habits, reducing the risk of lifestyle-related diseases such as obesity and diabetes later in life. In the present study, a public science fair setting was selected as it provides an opportunity to engage with individuals of various ages and educational backgrounds in an informal learning environment. Such events attract families, educators and children, thus creating an ideal setting for community-based health education. Moreover, the interactive nature of a science fair allows hands-on learning that is particularly effective in promoting health literacy and behavioural changes (Belfrage et al., 2023). To our knowledge, no previous studies have specifically assessed knowledge or awareness of gut microbiota among children and adults through interactive sessions designed to inform participants about this vital topic. This study aimed to: (1) evaluate the prior knowledge and awareness of gut microbiota among participants, (2) assess and compare knowledge gains among the participants about gut microbiota functions and benefits following the interactive educational session, and (3) evaluate participants' daily intake of fruits and vegetables and their willingness to incorporate these foods into their diet more regularly.

METHODOLOGY

Study Design and Setting

This cross-sectional study was conducted during the *Xporia Sains* science fair, held over three days in December 2023 at the *Pusat Sains Negara* (National Science Centre) in Kuala Lumpur, Malaysia. The event took place during the school holidays and was open to the public with free entry.

Participants

The interactive sessions were conducted from 9 AM to 5 PM daily, engaging approximately 500 visitors, mostly children accompanied by their teachers, parents, or grandparents. Verbal consent was obtained from all participants, including adults and the guardians of minors, before engaging in the study. Participants were thoroughly briefed on the study's objectives and assured of their right to withdraw at any point. All procedures adhered to ethical guidelines to ensure confidentiality and voluntary participation.

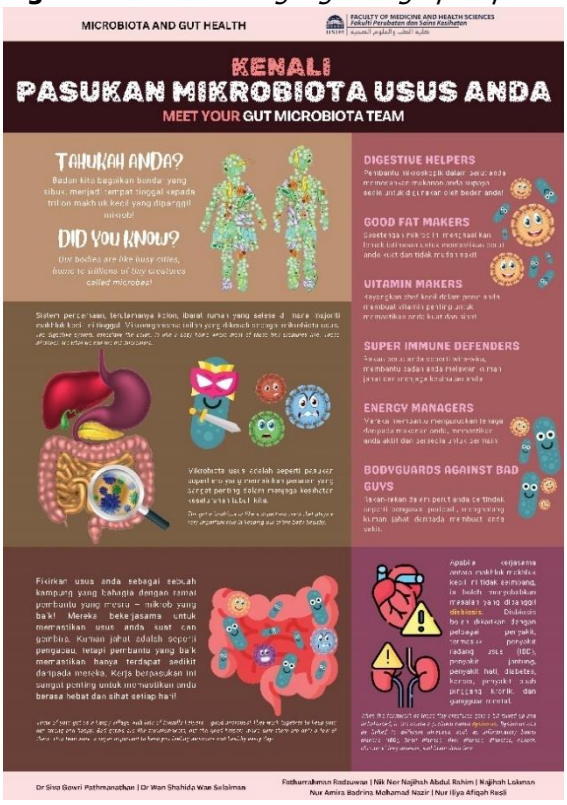
Facilitators

Third-year medical and postgraduate students from the Faculty of Medicine and Health Sciences, Universiti Sains Islam Malaysia (USIM), supervised by their Microbiology course lecturers, facilitated the fair activities. The facilitators were crucial in delivering educational content and guiding the interactive sessions.

Activities
The interactive booth comprised several educational and engaging activities:

Poster Presentation
The facilitators explained infographic posters (in Malay and English) on gut microbiota and ways to nurture a healthy gut (Figure 1). The posters provided information about gut microbiota and their functions, highlighting how factors such as diet, exercise, adequate sleep, and proper hydration nurture gut microbiota based on recent evidence from published literature.

Figure 1. *The dual-language infographic posters (in Malay and English) used in the interactive session.*



Demonstration Session
Visitors were asked to choose foods from a selection of plastic food models (fruits, vegetables, sweets, and ice cream) they liked to eat, and the facilitators explained which foods would likely encourage or nurture good gut microbiota.

Fun Quizzes
Participants attempted quizzes about gut microbiota using Quizziz. These quizzes were designed in layperson's terms to enhance knowledge. They were also self-assessing, with immediate feedback provided. To encourage participation, attractive prizes such as bookmarks and button badges with quotes on gut microbiota, probiotics and prebiotics for good health were given.

Questionnaire Administration
Finally, participants were asked to complete a printed questionnaire. The self-structured questionnaire was designed based on current literature and researchers' input. To ensure content validity, the questionnaire underwent an expert review involving a microbiologist, a public health physician, and a teacher. Feedback from this process was used to make necessary adjustments to improve question comprehensibility and relevance. The final version consisted 13 questions divided into three sections: prior knowledge and dietary habits (Yes/No format), knowledge gain (Yes/No format), and attitudes (5-point Likert scale). The specific questions are detailed in the Results section.

The questionnaires were printed out and administered in person immediately following the educational intervention. This ensured that participants were fully engaged and could directly apply what they had learned during the session, allowing for immediate assessment of knowledge gain. Facilitators were available to provide clarifications if needed, and the in-person questionnaire administration approach minimised potential biases related to self-administration and ensured consistent data collection, enhancing the reliability of responses.

Statistical Analysis

Data was transferred into IBM SPSS software v25. For descriptive analysis, age was categorised into age groups, representing pre-school, primary school, secondary school, young adults and so forth. Normality tests were conducted for continuous variables. Nonparametric tests were conducted to determine the difference in knowledge scores on microbiota between different age groups.

RESULTS

A total of 324 visitors participated in the interactive session. The youngest participant was five years old, while the oldest was 64; 40.4% of the participants were adults (Table 1). Almost two-thirds of the participants were females. School-aged children were the majority, with 188 out of 325 (57.8%). Nearly three-quarters of the school-aged children were from primary schools (73.94%), while the remaining were from secondary schools (26.06%).

Table 1. *Demographic profile of the participants, n=324*.

Characteristics	n	%
Age group		
< 7 years old	7	2.2
7 - 12 years old	135	42.9
13 - 17 years old	46	14.6
18 - 24 years old	32	10.2
25 - 39 years old	57	18.1
40 years old and above	39	12.1
Gender		
Male	111	36.2
Female	196	63.8
School Grade (n=188)		
Pre-school	4	2.1
Primary Year 1	15	8.0
Primary Year 2	11	5.9
Primary Year 3	24	12.8
Primary Year 4	26	13.8
Primary Year 5	25	13.3
Primary Year 6	34	18.1
Secondary Form 1	10	5.3
Secondary Form 2	13	6.9
Secondary Form 3	7	3.7
Secondary Form 4	9	4.8
Secondary Form 5	8	4.3
Secondary Form 6	2	1.1

Before the interactive session, 42.3% of the participants claimed to have heard of the term 'gut microbiota' (Table 2). More than half of them (57.2%) knew the human digestive system consists of trillions of microbes. Regarding fruit and vegetable intake, over two-thirds claimed to eat fruits daily, while over three-quarters ate vegetables daily.

Table 2. *Prior knowledge and dietary practices regarding gut microbiota, n=324.*

Item	Statement	Responses Yes n (%)	No n (%)	Unsure n (%)
1.	Before today, have you heard of the term 'gut microbiota'?	137 (42.3)	144 (44.4)	43 (13.3)
2.	Before today, did you know the human digestive system consists of trillions of microbes?	186 (57.2)	104 (32.0)	34 (10.5)
3.	Do you eat fruits every day?	224 (69.1)	81 (25.0)	19 (5.9)
4.	Do you eat vegetables every day?	252 (77.8)	56 (17.3)	16 (4.9)
5.	Do you bring fruit to school to eat during your school breaks?	115 (35.5)	175 (54.0)	34 (10.5)

Following the interactive session, most participants obtained correct answers to questions about gut microbiota, apart from the question on exercise effects (Table 3). This question was negatively worded. Only slightly more than half of the participants (54.0%) managed to get the correct answer. Analysis between the age groups showed that adults scored the most with knowledge about gut microbiota (Table 4).

Table 3. *Knowledge regarding gut microbiota, following the interactive session, n=324.*

Item	Statement	Responses Correct n (%)	Wrong n (%)	Unsure n (%)
1.	Trillions of microorganisms reside in our digestive tract.	274 (84.6)	12 (3.7)	37 (11.4)
2.	Gut microbiota helps with the digestion of the food we eat.	262 (80.9)	20 (6.2)	41 (12.7)
3.	Physical exercise encourages the growth of bad microorganisms in the gut.	175 (54.0)	110 (34.0)	38 (11.7)
4.	Eating yoghurt can introduce beneficial microbes called probiotics to the gut.	287 (88.6)	8 (2.5)	28 (8.6)
5.	Bananas contain prebiotics that support the growth of beneficial microbes in the gut.	265 (81.8)	16 (4.9)	42 (13.0)

Table 4. *Knowledge score on gut microbiota between different age groups, n=315.*

Age group	Median (IQR)	Mean rank	*p*-value
Primary school	4 (1.25)	138.93	
Secondary school	4 (1.00)	163.12	<0.001
Adults	4 (1.00)	177.46	

Based on the Kruskal-Wallis Test, significant to $p<0.05$
Post-hoc Mann-Whitney U tests showed that the significant difference was between adults vs primary school ($p<0.001$) only

An overwhelming 85.3% of participants agreed or strongly agreed to increase the intake of fruits and vegetables in their daily meals (Table 5). However, only 60.5% were willing to bring fruit to school or work to eat during break time. More than three-quarters (77.9%) of all participants agreed or strongly agreed that the session had helped increase their gut microbiota awareness.

Table 5. *Attitudes towards healthy gut microbiota practices following the interactive session*

Item	Statement	Response, n (%) Strongly disagree	Disagree	Unsure	Agree	Strongly agree
1.	Are you willing to increase the intake of fruits and	24 (8.4)	2 (0.7)	16 (5.6)	83 (29.0)	161 (56.3)

	vegetables in your daily meals?					
2.	Are you willing to bring fruit to school or work to eat during break?	24 (8.4)	10 (3.5)	56 (17.3)	74 (22.8)	122 (37.7)

DISCUSSION

The microbiota and gut health awareness questionnaire was developed, considering the crucial role of gut health in long-term overall health. Recent evidence has highlighted the impact of gut microbiota on various diseases, including metabolic disorders like diabetes, gastrointestinal conditions such as irritable bowel syndrome, and even neurological disorders like depression and anxiety (Fan & Pedersen, 2021; Queiroz et al., 2022). These effects are often mediated by microbial metabolites such as short-chain fatty acids, which play vital roles in metabolic and immune regulation (Wang et al., 2024). As such, the interactive session and questionnaire sought to introduce basic information about gut microbiota and raise participants' awareness of its importance in health.

The interactive session successfully engaged 324 participants, aged five to 64, demonstrating a broad age spectrum. The diverse age range indicates the broad appeal and the accessibility of the educational content. The demographic profile revealed a higher participation rate among school-aged children due to the science fair being held during the school holidays targeting students. Additionally, nearly two-thirds of the participants were female, and 40.4% were adults who accompanied the children. This suggests that future interventions could benefit by targeting families to enhance participation and impact.

Awareness of Gut Microbiota

Due to space constraints and to ensure a smooth flow of participants, we did not administer a pre- and post-questionnaire to evaluate their prior knowledge. Instead, our questionnaire (although answered after the interactive session) included inquiries about participants' prior knowledge. Before the session, less than half of the participants (42.3%) had heard of the term "gut microbiota," indicating a significant knowledge gap. This aligns with previous studies that found low public awareness of gut microbiota. These studies, though limited, targeted adult participants and, as such, assessed deeper knowledge of microbiota compared to the present study, such as the presence of bacteria in different parts of the body and the effect of antibiotics on microbiota. One study conducted among the general public (n= 402) found that most participants had a poor understanding of the role of microbiota in the body and their ability to confer illnesses (Barqawi et al., 2021). Another study among university students of various fields showed that, in general, students had good knowledge of microbiota. Still, those who took a microbiology course had significantly higher microbiota knowledge scores (Abu-Humaidan et al., 2021).

Targeting educational initiatives towards younger age groups is vital as it not only helps bridge the knowledge gap but also supports the establishment of healthy lifestyle patterns during formative years, which can be maintained into adulthood. The interactive session in the present study effectively increased knowledge, as evidenced by the high correct response rates to post-session questions. However, the lower correct response rate to the negatively worded question, "Physical exercise encourages the growth of bad microorganisms in the gut," suggests that question phrasing can impact understanding and response accuracy. Future studies should consider refining the questionnaire design to improve clarity and response accuracy.

Dietary Habits and Attitudes

Most participants reported daily consumption of fruits (69.1%) and vegetables (77.8%) before the session, suggesting a generally positive baseline dietary habit. Sociodemographic factors influence fruit and vegetable consumption in Malaysia, with household size, income, gender, marital status, age, and education significantly impacting the likelihood and amount of consumption (Lung et al., 2020). Post-session, an overwhelming 85.3% expressed willingness to increase their intake of fruits and vegetables, emphasising the potential of educational interventions to influence dietary behaviours. However, the

gap between willingness and practical implementation was evident, as only 60.5% were willing to bring fruit to school or work. This discrepancy highlights potential barriers such as convenience, availability, and personal preferences that must be addressed in future interventions. Longer-term educational interventions may be necessary to bridge this gap, as evidenced by a study where Malaysian overweight and obese school children showed improved fruit and vegetable intake after a 24-week nutrition education intervention (Selamat et al., 2021).

Educational Impact and Future Directions

The high agreement rate (77.9%) that the session increased participants' awareness regarding gut microbiota suggests that interactive and engaging educational activities have a significant effectiveness level. Indeed, interactive and engaging educational activities have significantly improved health awareness across diverse contexts. For example, web-based interactive health videos would enhance engagement and learning compared to static content (Lee, 2011). Similarly, technology-driven educational approaches and community-based interventions have significantly improved health literacy and behavioural changes in different populations (Adam et al., 2019; Rao et al., 2005). These findings collectively indicate that interactive and context-specific educational methods improve health awareness and encourage positive behavioural change effectively, supporting such approaches for public health initiatives.

Third-year medical and postgraduate students were essential in delivering the content. It demonstrated how the involvement of medical students in community health education is feasible. Involving medical students in community outreach not only benefits the participants but also enhance the student's learning experiences and aids in professional development. This aligns with the goals of national initiatives under the Malaysia Education Blueprint 2015-2025, which aims to bridge academic knowledge with community learning and service (MOE, 2015). Research has shown that university students involved in similar service-learning programs acquire useful experience and a deeper understanding of societal and public health issues (Cashman & Seifer, 2008; Naufal et al., 2024). Additionally, the participation of lecturers in such activities can further develop the educational experience by integrating recent research findings into community awareness programs, ensuring the dissemination of the latest scientific knowledge.

Limitations of Study

While the educational intervention demonstrated promising results in raising awareness about gut microbiota, the study has several limitations that should be considered when interpreting the findings. One of the key limitations of this study was the absence of a pre- and post-test design. Due to the flow of the science fair, it was difficult to administer both pre- and post-tests, as catching the respondents at two different time points was challenging. Therefore, while participants self-reported their prior knowledge, their actual baseline understanding of gut microbiota could not be fully quantified due to the lack of a pre-session questionnaire.

Another limitation was that the study was conducted at a public science fair during school holidays, possibly leading to a skewed sample. Participants were mainly school-aged children and their teachers or families, which may have limited the generalisability of the findings to other populations, such as adults without children or individuals who are not interested in attending such events. Besides that, the intervention was delivered in a short, one-time session, with no repeated, reinforced sessions, which may have limited its effectiveness. These limitations highlight areas for improvement in future research.

CONCLUSION

In conclusion, the interactive session at the *Xporia Sains* science fair effectively enhanced knowledge and positively influenced participant attitudes regarding gut health and healthy dietary practices that nurture gut microbiota. Future interventions could benefit from adopting a longitudinal approach and follow-up sessions to track participants over time and assess whether the knowledge gained leads to lasting behaviour change. Additionally, adapting this intervention to suit different educational levels and

integrating the content on gut microbiota awareness into school curricula could maximise the educational potential and ensure that this awareness influences lifelong habits.

Furthermore, continued efforts to include community service-learning models involving tertiary educators and students are necessary for enhancing public awareness and promoting healthier lifestyles. Such initiatives can serve as a model for incorporating public health education into academic curricula, fostering a generation of healthcare professionals equipped in community health.

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