

Scoby-Doo Unmasking the Gut Microbiota Through Hands-On Kombucha Making for Adolescents

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ABSTRACT

Gastrointestinal health is largely determined by the balance of the gut microbiota, a community of microorganisms that play a vital role in maintaining epithelial barrier function, modulating immune responses, and synthesizing essential metabolites such as short-chain fatty acids and vitamins. Disruption of this balance can trigger dysbiosis, which is associated with various digestive, inflammatory, and metabolic disorders. Therefore, maintaining a healthy microbiota through the intake of natural probiotics is an important preventive step that should be promoted early among adolescents. Interactive counseling was combined with a kombucha-making demonstration and tasting, using a fun-learning approach themed "SCOBY-DOO" to engage participants. Twenty-seven ninth-grade students of SMP Al Ma'soem Jatinangor participated fully. Knowledge was assessed using parallel pre-test and post-test instruments on microbiota and probiotics, analyzed with a paired-samples t-test and Cohen's d effect size. Analysis using the paired-samples t-test showed a significant increase in mean knowledge score from 80.96 on the pre-test to 92.85 on the post-test ($p < 0.001$). The Cohen's d effect size was 1.03, falling in the large category, indicating a substantial impact of the intervention. Attendance reached 90%, and all participants enthusiastically completed every activity stage, including hands-on practice and discussion. **Conclusion:** The fun-learning educational approach combined with hands-on fermentation practice proved highly effective in improving adolescents' digestive health literacy. Similar activities are recommended to be continued with longer discussion sessions

and additional interactive media, such as digital quizzes or animated videos, to deepen participants' understanding and reach more students

ABSTRAK

Kesehatan saluran cerna sangat ditentukan oleh keseimbangan mikrobiota usus, yaitu komunitas mikroorganisme yang berperan penting dalam menjaga fungsi sawar epitel, memodulasi respons imun, dan mensintesis metabolit esensial seperti asam lemak rantai pendek dan vitamin. Gangguan keseimbangan ini dapat memicu disbiosis yang berkaitan dengan berbagai gangguan pencernaan, inflamasi, dan metabolik. Oleh karena itu, menjaga kesehatan mikrobiota melalui asupan probiotik alami merupakan langkah pencegahan penting yang perlu digalakkan sejak dini pada remaja. Metode: Penyuluhan interaktif dikombinasikan dengan demonstrasi pembuatan kombucha dan sesi mencicipi, menggunakan pendekatan belajar menyenangkan bertema "SCOBY-DOO" untuk melibatkan peserta. Sebanyak 27 siswa kelas IX SMP Al Ma'soem Jatinangor berpartisipasi penuh. Pengetahuan dinilai menggunakan instrumen pre-test dan post-test paralel mengenai mikrobiota dan probiotik, lalu dianalisis dengan uji-t sampel berpasangan serta ukuran efek Cohen's d. Hasil: Analisis menggunakan uji-t sampel berpasangan menunjukkan peningkatan signifikan rerata skor pengetahuan dari 80,96 pada pre-test menjadi 92,85 pada post-test ($p < 0,001$). Nilai ukuran efek Cohen's d sebesar 1,03 termasuk dalam kategori besar, yang menandakan dampak intervensi yang substansial. Tingkat kehadiran mencapai 90%, dan seluruh peserta antusias menyelesaikan setiap tahapan kegiatan, termasuk praktik langsung dan diskusi. Kesimpulan: Pendekatan edukasi belajar-menyenangkan yang dipadukan dengan praktik fermentasi langsung terbukti sangat efektif dalam meningkatkan literasi kesehatan pencernaan remaja. Kegiatan serupa direkomendasikan untuk dilanjutkan dengan sesi diskusi yang lebih panjang serta penambahan media interaktif, seperti kuis digital atau video animasi, guna memperdalam pemahaman peserta dan menjangkau lebih banyak siswa.

PENDAHULUAN

Gastrointestinal health is an integral component of maintaining quality of life, particularly during adolescence, which is marked by hormonal changes, rapid growth, and shifting dietary patterns. One of the principal contributors to gastrointestinal homeostasis is the gut microbiota, a community of microorganisms living symbiotically within the human digestive tract. The gut microbiota participates in a range of vital functions, from the digestion of complex carbohydrates, the synthesis of vitamins K and B, and modulation of the immune system, to the maintenance of intestinal mucosal barrier integrity (Turnbaugh et al., 2007; Valdes et al., 2018).

An imbalance in microbiota composition, known as dysbiosis, can trigger various health problems, including infectious diarrhea, irritable bowel syndrome, inflammatory bowel disease, and metabolic and immunological disorders. Among adolescents, the consumption of fast food high in sugar and fat but low in fiber is one of the principal risk factors for dysbiosis. Data from the Ministry of Health indicate that the prevalence of functional gastrointestinal disorders among Indonesian adolescents shows an upward trend, making school- and community-based preventive efforts increasingly relevant and urgent (Travis, 2023).

One approach to maintaining gut microbiota balance is the consumption of probiotic-rich fermented foods. Kombucha, a tea beverage fermented using a “symbiotic culture of bacteria and yeast” (SCOBY), yields organic acids, polyphenols, vitamins, and probiotics that may modulate the gut microbiota and exert antioxidant and antibacterial effects (Chakravorty et al., 2016; Villarreal-Soto et al., 2018). Kombucha was selected as an educational medium because its ingredients and preparation steps are simple, can be replicated at home, and are appealing to adolescents.

Conventional educational approaches based on one-way lecturing are often less effective in conveying complex biological concepts to adolescents. Learning innovations that simultaneously integrate cognitive, affective, and psychomotor aspects are therefore greatly needed. The “SCOBY-DOO” theme—an adaptation of the popular character name Scooby-Doo combined with the term SCOBY—was chosen because it is familiar to students, easy to remember, and symbolically represents a mission to uncover the secrets of digestive health. This community service activity aimed to enhance students’ understanding of gut microbiota balance, to introduce the skill of making kombucha as an affordable source of probiotics, and to evaluate the effectiveness of the educational intervention by comparing pre-test and post-test scores.

Problems and Research Questions

Based on the background outlined above, three main problems were identified as the focus of this activity. First, the low level of understanding among junior high school students regarding the concept of the gut microbiota and its relationship to gastrointestinal health. Second, students’ limited access to practical education about natural sources of probiotics that can be produced independently. Third, the as-yet-unknown effectiveness of the “SCOBY-DOO” fun-learning approach in improving junior high school students’ knowledge of digestive health.

On the basis of these problems, three research questions were formulated as follows. (1) What is the level of understanding among students of SMP Al Ma’soem Jatinangor regarding the gut microbiota and the role of probiotics before and after the educational intervention? (2) How do students respond to a kombucha-making demonstration as a natural source of probiotics? (3) To what extent is the “SCOBY-DOO” fun-learning educational approach effective in improving digestive-health knowledge among adolescents?

The activity was conducted at SMP Al Ma'soem, located on Jalan Raya Cipacing No. 22, Jatinangor, Sumedang Regency, West Java. The partner site is approximately one kilometer from the campus of the Faculty of Medicine, Universitas Padjadjaran. A map of the activity location is presented in Figure 1.

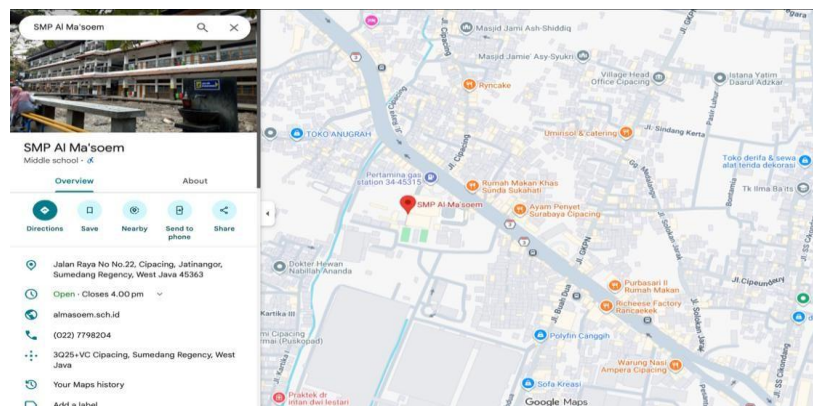


Figure 1. Map of the SCOBY-DOO activity location.

LITERATURE REVIEW

Gut Microbiota

The gut microbiota is a complex community of microorganisms comprising bacteria, viruses, fungi, and archaea that live symbiotically within the human digestive tract, particularly in the colon. Its composition is dynamic and is influenced by factors such as diet, environment, antibiotic use, and age. The number of microorganisms inhabiting the human digestive tract is estimated at 10^{13} to 10^{14} cells, nearly equal to or even exceeding the number of human body cells. This diversity is dominated by four major phyla—*Firmicutes*, *Bacteroidetes*, *Actinobacteria*, and *Proteobacteria*—with the *Firmicutes*-to-*Bacteroidetes* ratio frequently used as an indicator of an individual's metabolic status (Turnbaugh et al., 2007).

The principal physiological roles of the microbiota include the production of short-chain fatty acids (SCFAs)—among them butyrate, propionate, and acetate—as an energy source for colonic epithelial cells; strengthening of the tight junctions between epithelial cells; modulation of the mucosal immune system through interaction with gut-associated lymphoid tissue; and contributions to nutrient metabolism and the synthesis of vitamin K and B-complex vitamins (Portincasa et al., 2022; Hodgkinson et al., 2023). Dysbiosis has been associated with a range of pathological conditions, namely inflammatory bowel disease, irritable bowel syndrome, obesity, type 2 diabetes mellitus, and even neuropsychiatric disorders via the gut-brain axis (Sonnenburg & Sonnenburg, 2019).

Beyond its metabolic functions, the gut microbiota plays a central role in the development and regulation of the immune system. The continuous interaction between commensal microorganisms and gut-associated lymphoid tissue helps to shape the balance between

regulatory and effector T-cell populations, and disturbance of this balance has been implicated in the pathogenesis of autoimmune and chronic inflammatory conditions (Bhutta et al., 2024). Short-chain fatty acids are key mediators of this immunological cross-talk: in addition to serving as an energy substrate for colonocytes, butyrate and related metabolites reinforce epithelial barrier integrity, promote the differentiation of regulatory T cells, and exert anti-inflammatory effects beyond the gut, thereby linking microbial activity in the colon to systemic health outcomes (Mukhopadhyaya & Louis, 2025). These mechanisms underscore why an early understanding of the gut microbiota is relevant not only to digestive health but also to the broader long-term well-being of adolescents.

Probiotics and Fermented Foods

Probiotics are defined as live microorganisms that, when consumed in adequate amounts, confer a health benefit on the host. Commonly used genera include *Lactobacillus*, *Bifidobacterium*, and the yeast *Saccharomyces boulardii* (Sarita et al., 2025). The mechanisms of action of probiotics include competition for adhesion sites on the intestinal mucosa, production of antimicrobial compounds such as bacteriocins and organic acids, strengthening of the mucosal barrier by increasing the expression of tight-junction proteins, modulation of the mucosal immune response, and lowering of the intestinal luminal pH to inhibit colonization by pathogenic microorganisms (Vinayamohan et al., 2024).

Fermented foods are one of the easiest ways to obtain probiotics in everyday life. In addition to probiotics, fermentation also produces postbiotics—metabolites of microbial activity such as SCFAs, exopolysaccharides, and bioactive peptides that confer health benefits without requiring the presence of live cells (Rezac et al., 2018; Nyhan et al., 2022). Indonesia has a rich tradition of fermented foods such as tempeh, glutinous-rice and cassava tape, and oncom, which have the potential to serve as culturally and economically relevant sources of probiotics and postbiotics for Indonesian society.

The health benefits attributed to probiotics are increasingly understood to be strain-specific rather than generic, and contemporary research has moved toward the genomic characterization of individual strains in order to predict their functional properties. Comprehensive strain databases now catalogue the genetic features that underpin the health-promoting capacity of bifidobacteria and related genera, providing a rational basis for selecting probiotics with defined activities (Tarracchini et al., 2024). In clinical practice, probiotics are applied as adjuncts in the management of antibiotic-associated diarrhea, acute infectious diarrhea, and certain functional gastrointestinal disorders, although the strength of the evidence varies by indication and by the specific strain administered (Ambizas, 2025). For an educational program directed at adolescents, however, the priority is not the prescription of specific strains but the cultivation of an accurate conceptual understanding—namely, that beneficial

microorganisms can be obtained through ordinary, affordable foods rather than only through commercial supplements.

Kombucha as a Functional Beverage

Kombucha is a product of the fermentation of sweetened tea by a “symbiotic culture of bacteria and yeast” (SCOBY), which produces a polymeric cellulose pellicle through the activity of *Acetobacter* sp. During fermentation, yeasts hydrolyze sucrose into glucose and fructose and produce ethanol and carbon dioxide, while acetic acid bacteria convert ethanol into organic acids such as acetic, gluconic, and glucuronic acids, lowering the pH (Chakravorty et al., 2016; Villarreal-Soto et al., 2018). The bioactive compounds produced include organic acids, tea-derived polyphenols such as catechins and theaflavins, vitamins (B1, B2, B6, B12, and C), and enzymes that confer antioxidant and antimicrobial properties (Jayabalan et al., 2014; Kapp & Sumner, 2019).

The health benefits of kombucha include modulation of the gut microbiota, increased SCFA production, support for intestinal barrier function through colonization resistance, hepatoprotective effects, and the regulation of glucose and lipid metabolism. Kombucha also has an appealing sensory profile, with a mild sourness and natural carbonation that can serve as an alternative to the high-calorie sweet beverages commonly consumed by adolescents (Kim & Adhikari, 2020; Zubaidah et al., 2019).

The functional properties of kombucha are closely tied to the composition of its microbial consortium. Sequence-based analyses have demonstrated that, although the dominant members are consistently acetic acid bacteria and fermentative yeasts, the precise community composition varies between cultures and fermentation conditions, which in turn influences the spectrum of organic acids and bioactive compounds produced (Marsh et al., 2014). This variability has prompted growing interest in standardizing kombucha as a functional food and in characterizing its probiotic and antimicrobial properties for potential application in the food industry (Sharma et al., 2022). For the purposes of community education, this scientific complexity can be distilled into an accessible message: a living culture transforms a simple sweetened tea into a beverage with a distinctive flavor and potential health value, rendering the abstract concept of fermentation tangible and observable for students.

Health Education in Adolescents and Program Contribution

Junior high school students aged 12–15 years are in the formal operational stage, characterized by the capacity for abstract thinking, so that the microscopic concept of the microbiome can be comprehensively grasped (Gea et al., 2026). Global research demonstrates that eating habits established during adolescence tend to persist into adulthood, so that interventions during this period have a substantial long-term impact on the health profile of the population (WHO, 2023; Kemenkes RI, 2023).

This community service program contributes to improving public health literacy from an early age while also serving as a means for medical students to apply community medicine. The combination of scientific education and a kombucha-making demonstration provides experiential learning consistent with Kolb's learning theory. In addition, the activity contributes to the achievement of the Sustainable Development Goals, particularly the third goal of "good health and well-being" and "quality education," in line with the pillars of the Tri Dharma of Higher Education, namely community service.

From a pedagogical standpoint, adolescents in the formal operational stage benefit most from instruction that pairs abstract explanation with concrete, multisensory experience. The integration of a visual narrative theme, hands-on practice, and immediate sensory feedback engages the cognitive, affective, and psychomotor learning domains simultaneously, which is generally associated with stronger encoding and longer retention than lecture-based instruction alone. School settings are particularly well suited to such interventions because they reach a cohesive peer group during a developmental window in which dietary attitudes are still being formed and remain amenable to change, allowing a single well-designed activity to influence the health literacy of an entire class at once.

RESEARCH METHODS

This community service activity adopted an interactive educational method combined with a kombucha-making demonstration and tasting of the fermented product. The approach used was a SCOBY-DOO-themed fun-learning approach intended to increase participants' interest and engagement. The activity was conducted in person on Wednesday, 1 April 2026, at SMP Al Ma'soem Jatinangor, targeting ninth-grade students of class IX-E. The number of participants in attendance was 27 students out of a target of 30.

The activity was designed in several systematic stages following the rundown presented in Table 2. The first stage was a 10-minute pre-test to assess participants' baseline knowledge using a questionnaire of 15 multiple-choice questions on the gut microbiota, probiotics, intestinal barrier function, and fermented foods (see Appendix). The second stage was the delivery of educational material over 20 minutes, covering the definition of the gut microbiota, its physiological role in gastrointestinal health, the concept of probiotics, and an introduction to kombucha as an example of a fermented food. The third stage was a 30-minute kombucha-making workshop, in which participants were divided into four small groups of 6–7 students, each accompanied by two mentors.

Table 1. Rundown of the SCOBY-DOO activity

No	Activity	Duration (min)	Time	Person in charge
1	Mobilization	10	13.05-13.15	MC and Program team
2	Opening	10	13.15-13.25	MC
3	Pre-test	10	13.25-13.35	MC and all committee members
4	Educational material	20	13.35-13.55	Presenter
5	Mobilization for group division	5	13.55-14.00	MC
6	Workshop	30	14.00-14.30	Presenter + mentoring
7	Post-test	10	14.30-14.40	MC and all committee members
8	Closing	5	14.40-14.45	MC
9	Documentation	5	14.45-14.50	MC and Documentation team

Source: primary activity data, 2026

The materials used included black tea, granulated sugar, boiled water, kombucha starter, and a previously prepared SCOBY. Mentors guided each production stage while explaining the rationale and benefits of each step, from brewing the tea, dissolving the sugar, and cooling the tea to room temperature, to adding the starter and SCOBY and covering the jar with a breathable cloth. The fourth stage was kombucha tasting as a flavor introduction, followed by the fifth stage, a 10-minute post-test.

The pre-test and post-test instruments used parallel items assessing knowledge of the gut microbiota, probiotics, intestinal barrier function, and the kombucha fermentation process. Each instrument consisted of 15 multiple-choice questions with four answer options, with a maximum score of 100 points. Quantitative data were analyzed using a paired-samples t-test in SPSS version 27 to assess the significance of the score increase. Beforehand, the Shapiro-Wilk normality test was performed to confirm that the parametric assumptions were met. The effect size was

calculated using Cohen's d, with categories of "small" (0.2), "medium" (0.5), and "large" (≥ 0.8), and confirmed with the Hedges' g correction for small samples. The indicators of activity success were established as follows: participant attendance of at least 80%; an increase in the mean post-test score of at least 10 points compared with the pre-test; and full participation of attendees throughout the entire series of activities.

RESULTS AND DISCUSSION

Results

The results are presented in the order of the research questions. First, the knowledge measurement showed an increase in the mean score from 80.96 (SD 10.31) on the pre-test to 92.85 (SD 11.50) on the post-test, with a mean difference of 11.89 points (SD 11.55). The paired-samples t-test yielded $t = -5.350$ ($df = 26$) with $p < 0.001$, indicating that this increase was statistically significant. The 95% confidence interval for the mean difference ranged from -16.46 to -7.32 , entirely negative, confirming that post-test scores were consistently higher than pre-test scores. A Cohen's d effect size of 1.03, with a Hedges' g correction of 1.00, indicates a large impact of the intervention according to standard categories.

Table 2. Pre-test and post-test statistics of SCOBY-DOO activity participants

Variable	N	Mean	Standard Deviation	Standard Error
Pre-test	27	80.96	10.31	1.98
Post-test	27	92.85	11.50	2.21
Difference	27	11.89	11.55	2.22

Source: primary activity data, 2026

The distribution of individual scores showed that almost all participants improved, with some who initially obtained low pre-test scores (60–73 points) reaching 85–95 points on the post-test. Only a small proportion of participants showed decreased or stagnant scores, and further analysis indicated that this was related to remaining uncertainty regarding applied concepts, such as concrete examples of probiotic foods.

Second, participants showed high enthusiasm during the kombucha-making demonstration session. All groups successfully completed the production stages and actively asked questions about the fermentation mechanism and its health benefits. Frequently asked questions included how long kombucha should be fermented, whether kombucha is safe for daily consumption, and whether the SCOBY can be reused.

Third, all activity success indicators were achieved. Attendance reached 27 of 30 students, or 90%, exceeding the established threshold of 80%. All participants followed the series of activities from beginning to end. Activity documentation is presented in Figures 2, 3, 4, and 5.



Figure 2. Educational session on the gut microbiota and probiotics with students of class IX-E, SMP Al Ma'soem Jatinangor.



Figures 3 & 4. Kombucha-making workshop by small groups of students accompanied by student mentors.



Figure 5. Kombucha tasting session by the activity participants.

Discussion

The discussion is presented in the order of the research questions. First, the increase in the mean score from 80.96 to 92.85 ($p < 0.001$) is consistent with previous community service studies showing that nutrition and digestive-health education combining counseling with hands-on practice can significantly improve adolescents' knowledge (Gea et al., 2026). A Cohen's d effect size of 1.03 indicates a large intervention impact, exceeding the minimum threshold of 0.8. This reinforces the evidence that an approach combining cognitive elements (educational material) and psychomotor elements (practice) is more effective than one-way lecturing. By contrast, some participants still held misconceptions, such as regarding instant noodles as a source of probiotics and being unable to identify the colon as the primary site of the microbiota.

Compared with similar school-based studies, the score increase in this activity is relatively high. Previous studies in the context of basic biotechnology education at the junior high school level generally reported a mean increase of approximately 5–10 points, whereas the SCOPY-DOO activity produced a mean increase of 11.89 points. This difference is presumed to relate to three factors: the use of an appealing visual theme, participants' direct involvement in fermentation practice, and a relatively ideal mentor-to-participant ratio (1:3 to 1:4).

Second, the high enthusiasm during the kombucha-making workshop is consistent with experiential learning theory, which holds that direct experience strengthens knowledge retention. The variation in sensory responses shown by participants during kombucha tasting is consistent with sensory studies of kombucha in young populations, which report a tendency to prefer sweetness and a degree of novelty toward sour sensations (Kim & Adhikari, 2020). Some participants who were initially hesitant subsequently expressed interest after understanding the health benefits of kombucha, indicating that education about nutritional value can influence sensory acceptance.

Taken together, the three sets of findings are mutually reinforcing. The large knowledge gain, the high behavioral engagement during the workshop, and the full attainment of the success indicators suggest that the cognitive and affective effects of the intervention were complementary rather than independent: hands-on involvement appears to have increased attention and motivation, which in turn supported the acquisition of conceptual knowledge. This interpretation is consistent with the mechanistic literature reviewed above, in which the tangible transformation of sweetened tea by a living culture provides a concrete anchor for otherwise abstract ideas about microbial activity, fermentation, and the gut microbiota. By contrast, the residual misconceptions observed in a minority of participants—such as misclassifying instant noodles as a source of probiotics—indicate that a single session is sufficient to convey core principles but may be insufficient to fully correct pre-existing, culturally reinforced beliefs about food.

The low cost and simplicity of the materials also have practical implications for the scalability of the program. Because kombucha can be produced from inexpensive and widely

available ingredients, the intervention can in principle be replicated in other schools without specialized laboratory facilities, and its emphasis on locally familiar fermented foods such as tempeh and tape situates the health message within a culturally relevant frame. Sustaining the impact, however, would likely require follow-up activities that reinforce the core concepts and help translate knowledge into habitual dietary behavior, since a single exposure is unlikely to produce durable behavioral change on its own.

Third, the achievement of all success indicators, with 90% attendance and full participation, indicates that the SCOPY-DOO fun-learning approach was effective in capturing the attention of junior high school students. The use of a popular theme and appealing visuals facilitated the communication of complex scientific concepts, in line with the view that health education for adolescents needs to be designed to be culturally relevant to popular culture so that health messages can be absorbed.

Several limitations of the activity should be acknowledged. First, the sample was limited to a single class of 27 participants, so generalization of the results to the broader adolescent population should be undertaken with caution. Second, knowledge evaluation was conducted immediately after the intervention, so long-term retention was not measured. Third, the activity evaluation focused on the cognitive aspect, so concrete behavioral changes such as increased consumption of fermented foods were not measured.

CONCLUSIONS AND SUGGESTIONS

Based on the three research questions, the following conclusions can be drawn. First, the level of understanding among students of SMP Al Ma'soem Jatinangor regarding the gut microbiota and probiotics increased significantly after the educational intervention, with $p < 0.001$ and a large effect size. The mean score increase of 11.89 points shows that the educational instrument used was able to convey the key concepts effectively to participants. Second, students' responses to the kombucha-making demonstration were highly positive, marked by active involvement in all stages of the practice and interest in trying the fermented product. Third, the SCOPY-DOO fun-learning educational approach proved effective in improving digestive-health knowledge among adolescents, as shown by the achievement of all success indicators.

It is recommended that similar activities be continued periodically with longer discussion sessions and additional interactive media such as animated videos and prize quizzes to optimize participants' understanding. The reinforcement of basic concepts regarding the location of the microbiota and examples of probiotic sources needs to be strengthened to minimize misconceptions. Expanding the target audience to the senior high school level and other adolescent communities is also recommended to broaden the preventive impact against digestive disorders.

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