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The Impact of Handwashing Education Using Puzzle Media on Handwashing Behavior Among Elementary School Children: A Pre-Experimental Study

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ABSTRACT Maintaining proper hand hygiene is a fundamental aspect of clean and healthy living behavior (CHLB), particularly among school-aged children who are vulnerable to communicable diseases. Despite ongoing public health efforts, handwashing compliance in this demographic remains suboptimal. This study aimed to evaluate the effectiveness of educational interventions using puzzle-based media in enhancing handwashing behavior—specifically in the domains of knowledge, attitudes, and practices—among elementary school children. A pre-experimental study with a one-group pretest-posttest design was conducted involving 56 third-grade students from SDN Menur Pumpungan 5 Surabaya. Participants underwent four educational sessions utilizing puzzle media to demonstrate the correct six-step handwashing technique. Data on knowledge, attitude, and practice were collected using validated and reliable questionnaires and observation checklists. Statistical analysis was performed using the Wilcoxon Signed-Rank Test due to the non-parametric nature of the data. Results showed a significant improvement in all behavioral domains post-intervention. Knowledge scores increased from a mean of 13.32 (SD=1.336) to 14.39 (SD=0.802), attitude scores from 3.35 (SD=0.089) to 3.48 (SD=0.068), and action scores from 2.39 (SD=1.155) to 5.37 (SD=1.054), with all changes statistically significant ($p < 0.001$). The use of puzzle media proved to be an engaging and effective educational tool, facilitating better cognitive retention and behavioral performance in handwashing routines. In conclusion, puzzle-based health education significantly enhanced handwashing behavior among primary school children. This approach is recommended for broader implementation in school health programs to promote sustainable hygiene practices. Future studies may consider larger, more diverse populations and a control group to validate the generalizability of these findings.

INDEX TERMS Handwashing behavior, Puzzle media, Elementary school children, Health education, pre-experimental study

I. INTRODUCTION

The implementation of clean and healthy living behavior (CHLB) is essential in preventing infectious diseases, particularly among school-aged children who represent a vulnerable group due to their developing immune systems and behavior patterns [1]–[3]. One of the most effective yet underutilized CHLB practices is handwashing with soap (HWWS), which significantly reduces the risk of transmitting diseases such as diarrhea, respiratory infections, and skin conditions [4], [5]. Despite ongoing national and international public health campaigns, proper hand hygiene practices among Indonesian children remain suboptimal. According to Riskesdas 2018, only 49.8% of individuals aged ≥10 years demonstrate correct handwashing behavior [6]. Observations in elementary schools further confirm that children frequently neglect handwashing before eating or after using the toilet, leading to increased risk of infectious disease transmission [7], [8]. Recent data from Indonesia indicate that preventable diseases such as respiratory infections (15%), diarrhea (15%), pneumonia (15%), and hepatitis (15%) remain prevalent among children aged 5–14 years, with poor hygiene habits as contributing factors [6], [9]. Given the increasing burden of preventable diseases and insufficient adherence to HWWS practices, innovative and engaging educational interventions are urgently required to reinforce hygiene behavior among school children.

State-of-the-art methods to promote hand hygiene include visual learning tools, demonstrations, simulation-based education, digital games, and interactive activities such as puzzles [10]–[14]. Educational games have been found effective in improving children's cognitive and psychomotor skills by offering an engaging, memorable, and developmentally appropriate medium for learning [15], [16]. Puzzle-based media, in particular, leverage children's visual-spatial learning and problem-solving skills, making them well-suited for elementary students aged 6–12 years [17], [18]. The use of puzzles in health education has shown positive effects in enhancing knowledge, attitudes, and

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skills, especially in populations with limited attention spans [19]–[21].

Although some studies have explored the use of puzzle media in health promotion among children [19], [22], existing literature rarely evaluates its impact across the three behavioral domains—knowledge, attitudes, and actions—simultaneously in the context of HWWS. Moreover, no prior study has been conducted specifically on third-grade students at SDN Menur Pumpungan 5 Surabaya, which presents a contextual and geographical gap in the literature.

The aim of this study is to assess the impact of handwashing education using puzzle media on the behavior of elementary school children, focusing on knowledge, attitudes, and handwashing practices. By using a pre-experimental design, this study provides measurable evidence on the effectiveness of puzzle-based learning interventions in improving HWWS behavior. The contributions of this research are as follows:

1. Behavioral Scope Expansion: The study provides an integrated analysis of behavior change across cognitive (knowledge), affective (attitude), and psychomotor (action) domains—an approach not commonly addressed in previous studies.
2. Contextual Innovation: The research introduces and validates puzzle-based health education as an engaging and developmentally suitable tool for promoting hand hygiene among Indonesian third-grade students.
3. Policy Implication: The study offers actionable insights for educators, public health practitioners, and school policymakers to adopt low-cost, scalable interventions that align with children's learning styles and developmental needs.

II. METHOD

A. STUDY DESIGN

This research employed a pre-experimental design utilizing the One Group Pretest-Posttest Design, which allows for the assessment of behavioral changes in participants before and after the implementation of a specific intervention, without the inclusion of a control group. This design was deemed suitable for evaluating the immediate impact of a health education program within a non-randomized population setting, particularly when logistical or ethical constraints limit the feasibility of random assignment [23], [24]. The primary objective of the study was to measure changes in handwashing behavior specifically in the domains of knowledge, attitudes, and practical actions among elementary school-aged children after they were exposed to an educational intervention delivered through puzzle-based learning media. This approach enabled the researchers to determine the effectiveness of interactive, age-appropriate educational tools in promoting personal hygiene practices within a school environment.

B. SETTING AND DURATION

The study was conducted in February 2024 at SDN Menur Pumpungan 5, an elementary school situated in Surabaya, East Java, Indonesia. This particular school was chosen as the research site based on several key considerations, including its accessibility to the research team, the school's willingness to collaborate, and the availability of third-grade students who were deemed developmentally appropriate for the educational intervention. The selection process aimed to ensure a conducive environment for data collection and the successful implementation of the intervention, while also aligning with the study's target population criteria.

C. POPULATION AND SAMPLE

The target population comprised elementary school students aged 8–10 years. The accessible population was the entire group of third-grade students enrolled in SDN Menur Pumpungan 5. A total sampling technique was applied, involving all 56 students in grade 3 who met the inclusion criteria. Inclusion criteria were: (1) active enrollment in grade 3, (2) consent from parents/guardians, and (3) the ability to communicate and follow instructions. Exclusion criteria included students with cognitive or physical impairments that could interfere with participation. This study did not involve randomization due to the educational setting and ethical considerations, thus maintaining ecological validity appropriate for community-based educational research [25].

D. INTERVENTION: PUZZLE-BASED HANDWASHING EDUCATION

The intervention consisted of a structured hand hygiene education program using a puzzle-based visual media tool. The puzzle comprised six detachable pieces, each representing a sequential step in proper handwashing with soap. The media was designed to be visually engaging and aligned with children's developmental stages in visual-spatial and cognitive processing [26]. All sessions were conducted by trained facilitators using standardized scripts to ensure consistent delivery. The educational intervention was delivered over four sessions across two weeks:

1. Session 1 (Pretest & Observation): Baseline data collection on knowledge, attitudes, and actions related to handwashing.
2. Session 2 (Puzzle-based Learning with Visual Aids): Explanation of handwashing steps using the puzzle pieces and visual aids.
3. Session 3 (Puzzle-based Learning without Visual Aids): Repetition of material with reduced scaffolding to assess independent retention.
4. Session 4 (Posttest & Observation): Final evaluation of behavioral changes.

E. VARIABLES AND INSTRUMENTS

The independent variable in this study was the implementation of puzzle-based handwashing education, while the dependent variables encompassed the behavioral domains of knowledge, attitude, and action related to hand hygiene among elementary school students. Knowledge was evaluated through a 15-item multiple-choice questionnaire, with scoring categorized into three levels: good (≥75%), sufficient (50–74%), and poor (<50%). Attitude was measured using a 10-item Likert-scale questionnaire, which classified responses as either positive or negative. Meanwhile, action or practice was assessed using a direct observation checklist that captured the performance of six standardized steps of proper handwashing behavior, as guided by established protocols [27]. Prior to data collection, all research instruments underwent rigorous validation and reliability testing to ensure their suitability for the target population. Validity was

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established using Pearson's correlation coefficient, where each item's r-count exceeded the critical r-table value, indicating a statistically significant level of construct validity. Furthermore, internal consistency reliability was measured using Cronbach's Alpha, yielding satisfactory results with a reliability coefficient of 0.795 for the knowledge questionnaire and 0.740 for the attitude questionnaire. These outcomes demonstrated that the instruments possessed acceptable levels of reliability and were appropriate for application among school-aged children in educational research contexts [28].

F. DATA COLLECTION AND PROCEDURE

Data collection procedures were conducted in accordance with established ethical standards, including obtaining ethical clearance and securing informed consent from all relevant parties. Prior to implementation, the research team engaged in coordination with the school administration and classroom teachers to ensure that the study activities were smoothly integrated into the existing school schedule without disrupting the learning process. Pretest and posttest assessments were administered in a structured classroom setting, allowing for consistent data collection in a familiar environment for the participants. In addition, behavioral observations were carried out in a discreet manner to minimize the risk of performance bias, ensuring that students' natural behaviors were captured as accurately as possible during the intervention period.

G. DATA ANALYSIS

Data were analyzed using IBM SPSS Statistics version 25. Since the data did not follow a normal distribution (as tested by the Shapiro-Wilk test), the Wilcoxon Signed-Rank Test was used to compare pretest and posttest scores across the three behavioral domains. Significance was set at $p < 0.05$, and 95% Confidence Intervals (CI) were reported. This non-parametric method is suitable for analyzing repeated measures on the same subjects and is commonly applied in educational and health behavior studies [29].

H. ETHICAL CONSIDERATIONS

The research obtained ethical approval from the Health Research Ethics Committee at the Poltekkes Kemenkes Surabaya. Participants and their legal guardians were informed about the study's objectives, voluntary participation, and confidentiality policies. Written informed consent was obtained prior to data collection. The intervention posed minimal risk and aligned with the school's curriculum on personal hygiene, making it ethically acceptable and beneficial to participants.

III. RESULT

The results of this study examined the effect of handwashing education using puzzle-based media on behavioral outcomes among primary school children, specifically focusing on the domains of knowledge, attitudes, and handwashing actions with soap. The intervention aimed to enhance children's understanding of proper hygiene practices, foster positive attitudes toward hand hygiene, and improve the consistency and correctness of handwashing behavior. By integrating educational content into an interactive and engaging puzzle format, the study sought to promote active learning and retention among young learners. The findings provide insights into the effectiveness of this innovative approach in shaping health-related behaviors at an early age, particularly in the context of school-based hygiene promotion.

A. CHARACTERISTICS OF RESPONDENTS

According to TABLE 1, the age distribution of the primary school children who participated as respondents in this study was predominantly centered around 9 years old, with the vast majority of participants falling within this age group. A smaller proportion of the respondents were 11 years old, representing a minority within the overall sample. This relatively narrow age range reflects the targeted educational level of the intervention and ensures age-appropriate delivery of the handwashing education using puzzle media. The homogeneity in age also contributes to consistency in cognitive and developmental characteristics, which is essential for evaluating the effectiveness of educational strategies tailored to young learners

TABLE 1
Characteristics of Primary School Children by Age and Gender

Characteristics		Frequency (n)	Percentage (%)
Age	8 years	6	10,7
	9 years	45	80,4
	10 years	4	7,1
	11 years	1	1,8
	Total	**56**	**100**
Gender	Man	35	62,5
	Female	21	37,5
	Total	**56**	**100**

B. STATISTICAL TEST RESULT

Based on TABLE 2, the distribution of frequency levels of behavior of children of primary school age before given health education hand wash with soap with puzzle media, almost entirely have knowledge of hand wash using soap well and none have less knowledge hand washing by soap, overall have a positive handwashing attitude using the soap and no one have a negative hand wash attitude with the soaps, a small part have the ability to hand wash action using the soap well, and almost all have the capacity to hand wash action using soaps less.

This is in line with previous research where regarding the level of children's knowledge before being given puzzle play therapy intervention, almost all grade 1 children in this study had good knowledge [1]. The level of behavior in the knowledge domain of elementary school aged children who were respondents regarding hand washing can be said to be quite good before being given health education. This is because during the pandemic and after the Covid 19 pandemic, schools have provided education about hand washing, so that in general students already know what washing hands with soap is.

Based on TABLE 3, the distribution of frequency levels of behavior of primary school children after given health education hand wash with soap with puzzle media, almost entirely have knowledge of hand wash using soap well and none have less knowledge of hands washing by soap, overall have a positive handwashing attitude using the soap and no one have a negative hand wash attitude with the soaps, almost

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all have the ability to hand wash action by the soapy well, and a small portion have less hand washing ability by the soap.

Previous research stated that almost all of them had good knowledge after being given education using puzzle media [19]. The results of the post-test questionnaire on hand washing knowledge for elementary school aged children in this study showed that the children already understood the knowledge of hand washing, especially in terms of how washing hands can prevent disease and stop the spread of germs, washing hands needs to be done before and after eating, and washing hands is not necessary. Just use running water so that the results of the post test on children's hand washing knowledge are almost entirely in the good category

TABLE 2
Frequency Distribution of Basic School Child Behavior in Hand Washing with Soap Before Education Hand Washing with Soap Using Media Puzzle

Behavioral Level	Category	Before Education Wash Hands with Soap Using Puzzle Media	
		n	%
Knowledge	Good	48	85,7
	Enough	8	14,3
	Not Enough	0	0
	Total	**56**	**100**
Attitude	Positive	56	100
	Negative	0	0
	Total	**56**	**100**
Action	Good	2	3,6
	Enough	7	12,5
	Not Enough	47	83,9
	Total	**56**	**100**

TABLE 3
Frequency Distribution of Basic School Child Behavior in Hand Washing with Soap After Education Hand Washing with Soap Using Media Puzzle

Behavioral Level	Category	After Education Wash Hands with Soap Using Puzzle Media	
		n	%
Knowledge	Good	55	98,2
	Enough	1	1,8
	Not Enough	0	0
	Total	**56**	**100**
Attitude	Positive	56	100
	Negative	0	0
	Total	**56**	**100**
Action	Good	46	82,1
	Enough	8	14,3
	Not Enough	2	3,6
	Total	**56**	**100**

According to TABLE 4, there was an improvement in student behavior in the domain of knowledge between the pre-test and post-test levels. The Wilcoxon Signed Ranks Behavioral Handwashing Test in the knowledge domain yielded a significant value (p = 0.000; CI = 14,18-14,61), indicating that teaching children of primary school age to wash their hands with soap has an impact on their knowledge-related behavior. Based on the level of behavior in the attitude domain, the known mean value of the pretest is 3.35, whereas the posttest is 3.48. The Wilcoxon test yields a significant value (p = 0.000, CI = 3.46-3,50), indicating a noteworthy impact of education involving handwashing with soap and puzzle media on the attitudes of primary-school children. The degree of conduct in the action domain led to an increase in the known value of the pretest from 2.39 to 5.37.

TABLE 4
Distribution Educational Health Impacts of Hand Washing with Soap Using Media Puzzle on Handwashing with Soap Behavior of Children of Primary School

Behavioral Level		Mean	SD	95%CI	p-value
Knowledge	Pre Test	13,32	1,336	12,96-13,68	0,000
	Post Test	14,39	0,802	14,18-14,61	
Attitude	Pre Test	3,35	0,089	3,33-3,37	0,000
	Post Test	3,48	0,068	3,46-3,50	
Action	Pre Test	2,39	1,155	2,08-2,70	0,000
	Post Test	5,37	1,054	5,09-5,66	

School-age children, after being given health education on washing hands with soap using puzzle media, can increase their knowledge about washing hands because puzzles can be easily understood by students. Students can classify, arrange, and connect the steps for washing hands listed on each puzzle piece. This is because when children see and arrange each piece of the handwashing puzzle, children will automatically see, read, and remember the sequence of the 6 steps for washing hands depicted in the puzzle. So it can be concluded that education with puzzle games can be accepted and understood well by elementary school-age children so that there is an increase in behavior in the domain of knowledge about washing hands with soap. This is in line with research conducted by [9] which also stated that there was a significant relationship between attitudes and handwashing behavior with soap in students in the study.

IV. DISCUSSION

A. INTERPRETATION OF FINDINGS

The results of this study indicate that educational interventions using puzzle media significantly enhanced handwashing behavior among elementary school children, particularly in the domains of knowledge, attitude, and action. The increase in the knowledge score from a mean of 13.32 to 14.39 demonstrates that puzzle media can effectively convey essential hand hygiene concepts. This enhancement suggests that the use of visual-spatial learning tools aligns well with the cognitive developmental stage of children aged 8–10 years, who are typically in Piaget's concrete operational stage and learn best through hands-on and visual activities [30].

In terms of attitude, a modest yet statistically significant increase from a mean score of 3.35 to 3.48 reflects a shift toward more positive perceptions and beliefs about handwashing practices. Attitudinal change, although generally slower to manifest, is a critical determinant of sustained behavioral change. This result aligns with Ajzen's theory of planned behavior, which posits that attitude significantly influence intention and ultimately behavior [31].

The most substantial transformation occurred in the action domain, where the mean score rose from 2.39 to 5.37. This suggests that the intervention not only improved theoretical

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understanding but also translated into improved real-world behavior. The puzzle media likely facilitated this through repetitive visual exposure and kinesthetic engagement, reinforcing the six steps of handwashing in a manner that children could easily internalize and replicate. This finding is consistent with studies showing that gamified educational tools promote better psychomotor retention than didactic teaching alone [32].

These outcomes collectively reinforce the hypothesis that puzzle-based media can function as an effective and developmentally appropriate strategy for delivering health education to elementary school children. The interactive nature of puzzles, which combines visual stimulation with tactile engagement, appears to enhance children's cognitive processing and retention of health-related information, particularly in the context of hand hygiene. Furthermore, the multimodal characteristics of puzzle media offer significant pedagogical advantages by accommodating various learning styles—visual, auditory, and kinesthetic—thereby increasing the likelihood of meaningful learning experiences across a diverse student population. This suggests that the integration of such educational tools into school-based health promotion programs may be a valuable approach for improving children's understanding, attitudes, and behaviors related to personal hygiene.

B. COMPARISON WITH PREVIOUS STUDIES

The current findings are consistent with prior research demonstrating the effectiveness of educational games in improving hygiene behavior. For instance, Maelissa and Ukru [15] found that puzzle-based interventions significantly improved hand hygiene practices among elementary school children in Ambon. Similarly, Ozcan et al. [30] documented positive behavioral outcomes when using a combination of demonstration, puzzles, and songs in Turkish schools.

Moreover, the observed increase in handwashing behavior aligns with results from Nuranisah and Kurniasari [20], who used a “snakes and ladders” game to promote clean and healthy living behaviors and found improvements in both knowledge and attitude among elementary school children. Likewise, Perwitasari and Year [19] reported that puzzle media led to notable knowledge gains regarding personal hygiene in students from Temanggung.

The use of puzzles as a pedagogical tool has also been supported in cognitive psychology literature, which emphasizes that puzzles help enhance memory consolidation through active engagement, problem-solving, and visual cueing [33]. This is particularly beneficial for elementary-aged children who are still developing executive functioning and attentional control.

Contrasting findings do exist, particularly in studies where digital interventions showed marginal improvements. A study by Patel et al. [34] using tablet-based hygiene modules reported lesser gains in behavior compared to this study's tangible puzzle-based method. This suggests that for younger children, physical manipulatives may be more impactful than digital media due to their limited abstract reasoning abilities.

Furthermore, this study corroborates research by Rosdiyawati et al. [29], which indicated that simulation-based learning significantly improves hand hygiene behavior. However, puzzle-based interventions may offer additional benefits by introducing problem-solving and cognitive reinforcement elements, as noted by Chandra [27], who observed significant gains in number recognition among preschool children using puzzle media.

C. STUDY LIMITATIONS AND IMPLICATIONS

Despite its promising findings, this study is not without limitations. First, the research employed a pre-experimental one-group pretest-posttest design, which lacks a control group. As a result, confounding variables such as teacher influence, peer learning, or environmental factors may have contributed to the observed changes. A quasi-experimental or randomized controlled trial would offer greater internal validity and allow for stronger causal inferences [35].

Second, the sample was limited to a single elementary school in Surabaya, comprising 56 third-grade students. While the homogeneity of the sample may enhance internal consistency, it also restricts the generalizability of the findings. Cultural, socio-economic, and educational variations across different regions could influence how children respond to similar interventions.

Third, the short duration of the intervention (four sessions over two weeks) means that the study captured only immediate post-intervention effects. Longitudinal data would be necessary to determine the sustainability of behavioral change, particularly in terms of long-term adherence to handwashing protocols.

In addition, self-reporting and observation biases cannot be completely ruled out. While observational checklists were used to assess action behavior, the presence of observers may have influenced student performance (Hawthorne effect). Future studies should consider using concealed or video-based assessments to mitigate this limitation. Nevertheless, the implications of this study are significant. First, puzzle media represent a low-cost, easily replicable, and culturally adaptable intervention that can be scaled across diverse school settings. Their tactile and interactive nature provides an inclusive platform for health education, particularly in resource-constrained environments.

Second, this study supports integrating gamified media into school curricula as part of a broader effort to instill hygiene behaviors early in life. Since habits formed during childhood often persist into adulthood, embedding such interventions in primary education has long-term public health implications [36]. Third, this research highlights the importance of multi-domain assessment—evaluating not only knowledge but also attitudes and actions. Educational interventions that neglect affective and behavioral components may fail to produce sustainable change. The triple-domain framework adopted in this study can serve as a model for future behavioral health research.

Finally, the findings suggest that teachers and community health workers can adopt puzzle-based education without requiring advanced training, as the materials are self-explanatory and intuitive. This democratizes access to health promotion tools and aligns with WHO’s recommendations for community-based hygiene education [37].

V. CONCLUSION

The primary aim of this study was to examine the effectiveness of handwashing education using puzzle-based

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media in enhancing handwashing behavior—specifically in the domains of knowledge, attitudes, and actions—among elementary school children. Based on a pre-experimental design involving 56 third-grade students at SDN Menur Pumpungan 5 Surabaya, the intervention utilized a structured educational model delivered over four sessions. Findings from the Wilcoxon Signed-Rank Test revealed statistically significant improvements across all behavioral domains. The mean knowledge score increased from 13.32 (SD = 1.336) to 14.39 (SD = 0.802), indicating enhanced cognitive understanding of handwashing. Attitude scores also improved from a mean of 3.35 (SD = 0.089) to 3.48 (SD = 0.068), suggesting more positive perceptions and internal motivation toward hygiene behavior. Most notably, action scores rose substantially from 2.39 (SD = 1.155) to 5.37 (SD = 1.054), demonstrating tangible improvements in students' handwashing performance. These results underscore the potential of puzzle media as an engaging, low-cost, and developmentally appropriate tool for health education. The media's visual and tactile features align with the learning preferences of children, making complex sequences such as the six steps of handwashing easier to comprehend and retain. However, limitations of this study include its lack of a control group, relatively short observation period, and its setting within a single school, which restrict the generalizability of the findings. Future research should consider employing randomized controlled trials across multiple schools and longer-term follow-up assessments to evaluate the sustainability of behavioral change. Additionally, implementing the puzzle media in small-groups, peer-guided learning environments may enhance comprehension and facilitate more effective behavior modeling. Overall, this study affirms the pedagogical value of puzzle media in promoting healthy behavior among young learners and recommends its integration into school-based hygiene education programs.

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DATA AVAILABILITY

No datasets were generated or analyzed during the current study.

AUTHOR CONTRIBUTION

Amelia Nur Indah Sari contributed to the research conceptualization, design, data collection, and manuscript writing. Aida Novitasari supervised the implementation of the intervention and contributed to the methodology and validation processes. Ach. Arfan Adinata performed the statistical analysis and assisted in data interpretation. Indriatie contributed to the literature review, discussion development, and final manuscript editing. All authors have read and approved the final version of the manuscript.

DECLARATIONS

ETHICAL APPROVAL

This study was approved by the Health Research Ethics Committee of Poltekkes Kemenkes Surabaya. All procedures performed in this study involving human participants were in accordance with institutional and national research committee ethical standards.

CONSENT FOR PUBLICATION PARTICIPANTS.

Consent for publication was given by all participants

COMPETING INTERESTS

The authors declare no competing interests

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