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Integrating gamification to increase users' engagement to adhere COVID-19 interventions using extended TAM

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ABSTRACT

Gamification has shown potential for enhancing motivation and engagement, yet its effectiveness in promoting adherence to COVID-19 preventive measures remains underexplored. With decreasing public attentiveness, this study examines the role of gamification in encouraging compliance with health protocols through an extended technology acceptance model (TAM) and structural equation modeling (SEM). A gamified mobile application was developed, incorporating features such as points, badges, and progress tracking, and was designed to appeal to younger audiences. Data collected from 150 secondary school students in Sarawak, Malaysia, indicated that perceived usefulness, perceived ease of use, and attitude toward the app significantly influenced engagement with COVID-19 preventive measures. Among these factors, perceived usefulness demonstrated the strongest effect on engagement ($\beta = 0.424$, $t = 4.812$, $p < 0.001$). The findings highlight the potential of gamification to enhance compliance with COVID-19 protocols.

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1. INTRODUCTION

The COVID-19 pandemic has created major challenges for global public health. Governments and health organizations have introduced measures like mask-wearing, social distancing, handwashing, and vaccination to slow the virus [1], [2]. These strategies have been effective, but many people struggle to follow them consistently [3], [4]. This inconsistency is dangerous as new variants of the SARS-CoV-2 virus emerge, making vaccines alone insufficient [5], [6]. New ways to promote long-term adherence to these measures are urgently needed.

One key issue is the public's over-reliance on vaccines as the main form of protection [4]. Vaccines are important but do not guarantee full immunity, especially as the virus mutates [5], [6]. This reliance has caused a drop in other essential behaviors, like wearing masks and social distancing. Many people abandon these practices after vaccination [4].

To address this, researchers are exploring ways to boost public compliance. Health campaigns have increased mask use [2], and mobile apps have promoted social distancing [7]. However, keeping people engaged long-term remains a challenge. Gamification, which uses game-like elements such as rewards and leaderboards, has emerged as a potential solution [8]–[10]. It motivates users through competition and achievement [11], [12]. While promising, gamification for COVID-19 prevention is not yet well-studied. Evidence of its effectiveness in sustaining health behaviors is still limited [13], [14].

This study examines how gamification can improve engagement with COVID-19 measures. It uses the technology acceptance model (TAM) [15], [16] to guide the approach. TAM explains how perceived usefulness and ease of use affect people's acceptance of new tools [17], [18]. By combining TAM and gamification, the study aims to explore their potential to increase long-term adherence to preventive measures.

2. METHOD

2.1. Research proposed framework and model

This study explores how gamification impacts user behavior in adopting COVID-19 preventive measures. It builds on earlier research focusing on factors like gamification, perceived usefulness, ease of use, attitude, participation, and engagement [19]–[21]. The TAM serves as the conceptual foundation for the research, providing a robust framework for understanding how users adopt new technologies.

2.2. Structural equation modeling (SEM)

SEM was employed to evaluate the proposed hypotheses, following the approach described by [22]. The process began by checking key assumptions. These included having a sufficient sample size, normal data distribution, independence, no outliers, and low collinearity. The model was specified by defining causal paths between variables based on theory and past studies. The identification and estimation phases were conducted to validate the model and assess its overall fit. Various indices were used to evaluate the model's quality, and adjustments were made as needed to improve the fit.

2.3. Hypotheses development

2.3.1. Gamification perceived ease of use (GEOU)

Gamification perceived ease of use (GEOU) comes from Davis's TAM theory [16]. It refers to how simple users find the gamified system to use [23]. Building on this, the following hypotheses were developed:

H1: Perceived ease of use enhances users' perception of the usefulness of gamification in practicing COVID-19 preventive measures.

H2: Perceived ease of use has a favorable effect on users' attitude towards using gamification for COVID-19 preventive measures.

H3: Perceived ease of use boosts user engagement.

2.3.2. Gamification perceived usefulness (GPU)

Gamification perceived usefulness (GPU) is a key concept in TAM. It refers to the belief that gamification helps people follow COVID-19 preventive measures [24]. Past studies have shown its importance in influencing user attitudes and engagement [20], [25], [26]. Given this, the following hypotheses were suggested:

H4: Perceived usefulness positively affects users' attitude towards using gamification technology for COVID-19 preventive measures.

H5: Perceived usefulness increases users' engagement.

2.3.3. Attitude towards using gamification

Attitude towards using gamification is users' overall perception of gamification [20]. In response, a hypothesis was developed:

H6: Users' attitude towards using gamification technology has a favorable impact on their engagement.

2.3.4. Users' engagement

The main focus of this study is user engagement, especially regarding COVID-19 measures. In the context of COVID-19, user engagement is crucial for the success of preventive actions. Looyestyn *et al.* [27] emphasize that engagement can involve either a single instance or long-term involvement in an activity, which is vital for sustained adherence to health guidelines. Without continuous engagement, measures like mask-wearing, social distancing, vaccination, and public health campaigns may become less effective [28], [29]. By leveraging gamification strategies, this study aims to enhance user engagement, promote behavior change, and improve the effectiveness of COVID-19 interventions in safeguarding public health [30], suggesting that user engagement refers to stimulating users to engage in desired behaviors with greater enthusiasm and encouraging their active participation. To illustrate the research model and the hypotheses being tested, we proposed X-Tended gamification acceptance model (X-GAM). Figure 1 shows a visual depiction of the proposed research model.

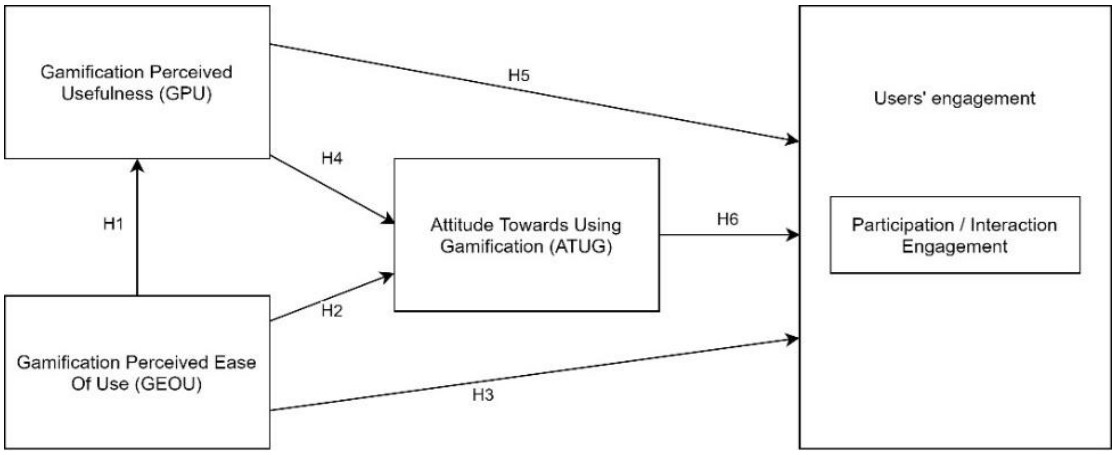
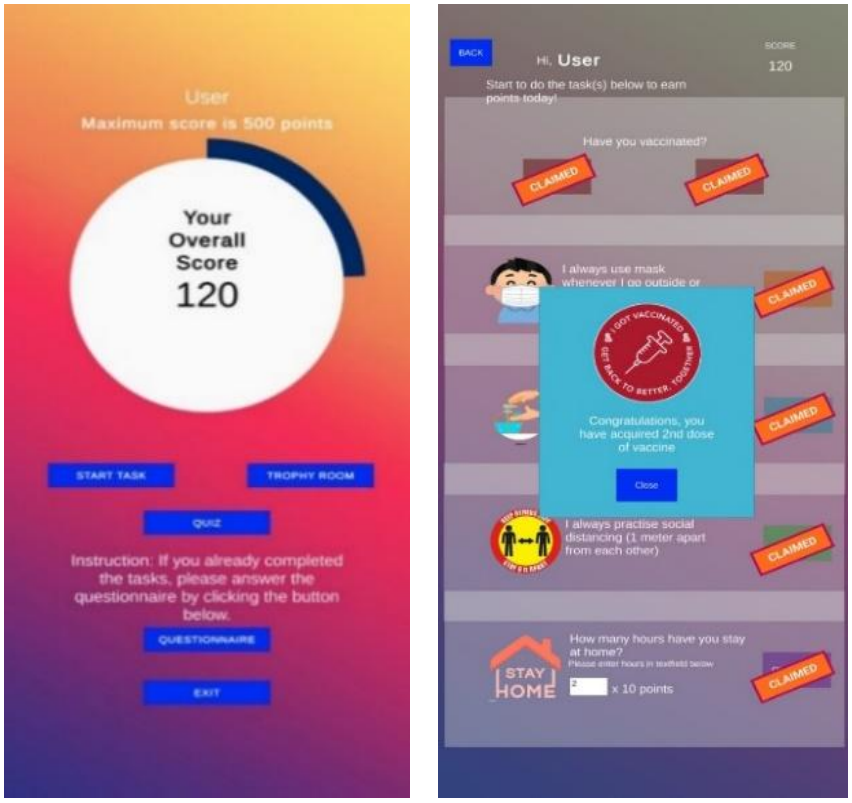


Figure 1. Proposed research model and hypotheses

2.4. Gamified COVID-19 mobile application

The app in this study motivates users to adhere to COVID-19 preventive guidelines through gamification features, including rewards like points, badges, levels, and feedback, all centered around WHO-recommended actions. The user interface is simple and easy to navigate, featuring a cohesive visual design. The design is straightforward and user-friendly, with a clean and consistent visual layout. Users accumulate points and rewards for finishing tasks and quizzes related to COVID-19 precautions, and their progress is reset daily to encourage continuous participation. Figure 2 illustrates the key components of the gamified COVID-19 mobile application. Figure 2(a) displays the main menu showing users' overall scores, while Figure 2(b) displays a list of tasks users can complete.



(a) (b)

Figure 2. The user interfaces for (a) main menu and users' overall scores and (b) task list screen

2.5 Research design and data collection

2.5.1. Measurement item design

The study gathered data through an online questionnaire. The measurement items were based on previous studies, adjusted for gamification, usefulness, ease of use, attitude, and users' engagement. Gamification variables were assessed with four items, and user engagement with three items, all on a 5-point Likert scale. A pilot survey helped refine the questions and ensure validity. Table 1 lists the indicators of the X-Tended gamification acceptance model (X-GAM) and the related survey questions.

Table 1. Indicators of X-tended gamification acceptance model and survey questions

Code	Survey question	Indicators	Ref.
GPU	Using the gamification app boosts my motivation to adhere to COVID-19 preventive measures.	Improve task completion	[31]
	Using the gamification app enhances my ability to follow COVID-19 preventive measures.	Frequency/Efficiency	[32]
	Using the gamification app improves my efficiency in following COVID-19 preventive measures.	Enhance work performance	[33]
	Using the gamification app is useful in following preventive measures of COVID-19.	Useful	[33]
GEOU	I find the gamification app easy to use and adaptable.	Flexible	[33]
	The functionality and design of the gamification app are straightforward and easy to comprehend.	User friendly	[33]
	Using the gamification app doesn't demand much mental effort from me.	Effortless	[33]
	In general, I think the gamification app is user-friendly.	Easy to use	[33]
ATUG	I believe using the gamification app is an effective way to continue following COVID-19 preventive measures.	Feelings	[33]
	The gamified app has made following COVID-19 preventive measures more engaging.	Affectionate	[33]
	Playing the gamified app was fun.	Desire	[33]
	I like practicing the preventive measures using the gamified app.	Instill positivity	[33]
UE	This gamified app contributes to me in having fun in following the preventive measures of COVID-19.	Interaction	[33]
	This gamified app motivates me to willingly adhere to COVID-19 preventive measures.	Voluntarily	[33]
	This gamified app helps me make noticeable progress in complying with COVID-19 preventive measures.	Desired outcome	[33]

2.6. Sampling and procedures

The questionnaire had two sections: one for demographic data and another for measuring key variables. Conducted online between January 31st and February 14th, 2022, the survey received 170 responses from secondary school students, with 150 valid responses analyzed after removing incomplete submissions. Incomplete surveys were excluded to ensure data quality, defined by unanswered key questions or inconsistent responses. The final sample consisted of predominantly young mobile phone users aged 16-18, with 47% male and 53% female. Age distribution was 29% (16-year-olds), 38% (17-year-olds), and 33% (18-year-olds).

3. RESULTS AND DISCUSSION

SEM was performed using AMOS 26 software to evaluate the hypotheses and analyze the data. SEM enables a comprehensive examination by measuring both the direct and indirect impacts of independent variables on dependent variables. This approach helped evaluate relationships between the constructs in our framework. It provided insights into how gamification influences user engagement with COVID-19 preventive measures. SEM also accounts for measurement errors, making the results more accurate and reliable.

3.1. Analysis and result

Varimax rotation in factor analysis was applied to pinpoint key variables such as gamification's perceived usefulness, ease of use, attitude towards gamification, and user engagement. The kaiser-meyer-olkin (KMO) value was recorded at 0.949, significantly exceeding the minimum recommended threshold of 0.6, confirming that the sample size was adequate for conducting factor analysis [34].

3.2. Measurement fit

AMOS employed multiple goodness-of-fit metrics to obtain maximum likelihood estimation (MLE) from a covariance matrix. Following Alamri *et al.* [35], a set of goodness-of-fit measures was used to determine the model's suitability. Based on the values that were found, the model did meet the conforming fit goodness criterion. Table 2 summarizes the goodness-of-fit indices of the model.

3.3. Convergent and discriminant validity

Data analysis was performed using SPSS 26.0 software. As stated by Knekta *et al.* [36], each measurement item's factor loading must exceed 0.40 to be included in the analysis. Table 3 shows that all factor loadings exceeded this threshold, validating the retention of all measurement items for subsequent analysis.

Table 2. Summary of goodness fit indices

Types of measures	Recommended values	Tested model
X^2/d.f	< 5.0	1.232
Goodness of fit (GFI)	> 0.90	0.916
Root-Mean Residual (RMR)	Close to 0	0.042
Incremental Fit Index (IFI)	≥ 0.90	0.979
Tucker Lewis Index (TLI)	≥ 0.90	0.974
Comparative Fit Index (CFI)	≥ 0.90	0.979
Root mean square error of approximation (RMSEA)	< 0.10 (Good), < 0.05 (Very Good)	0.045

Table 3. Cronbach's a of measuring and confirmatory factor analysis

Construct	Items	Cronbach's a	Factor loading	CR	AVE
GPU1	Q1	0.816	.769	0.8993	0.6901
GPU2	Q2		.720		
GPU3	Q3		.775		
GPU4	Q4		.752		
GEOU1	Q5	0.789	.651	0.9203	0.7433
GEOU2	Q6		.740		
GEOU3	Q7		.567		
GEOU4	Q8		.768		
ATUG1	Q9	0.809	.830	0.8926	0.6765
ATUG2	Q10		.621		
ATUG3	Q11		.772		
ATUG4	Q12		.744		
UE1	Q13	0.780	.691	0.8645	0.6810
UE2	Q14		.729		
UE3	Q15		.805		

Figure 3 shows that all factor loadings for the measurement items were above 0.40, indicating strong links between the items and their corresponding constructs. This threshold confirms that each measurement item contributes adequately to its corresponding factor, justifying the retention of all items for further data analysis. Keeping these items helps maintain the reliability and validity of the measurement model, strengthening the results from the SEM analysis.

Reliability was assessed through Cronbach's alpha and composite reliability metrics. A Cronbach's alpha score exceeding 0.7 reflects adequate construct reliability [37], [38]. Similarly, composite reliability (CR) values above 0.70 and average variance extracted (AVE) values over 0.5 are deemed satisfactory [39]. As noted by Churchill [40], these benchmarks establish the reliability of the constructs. Additionally, AVE values higher than 0.50 indicate strong construct validity. Table 4 presents the findings of the reliability and validity analysis.

Discriminant validity ensures that indicators are correctly linked to their construct. The results show that the square roots of the AVE for each construct were higher than their correlations with other constructs, confirming good discriminant validity. Convergent validity for the constructs was also adequate.

Table 4. Discriminant validity

Factors	GPU	GEOU	ATUG	UE
Gamification Perceived Usefulness (GPU)	**0.831**			
Gamification Perceived Ease of Use (GEOU)	0.746	**0.862**		
Attitude towards Using Gamification (ATUG)	0.827	0.743	**0.822**	
Users' engagement (UE)	0.792	0.678	0.78	**0.825**

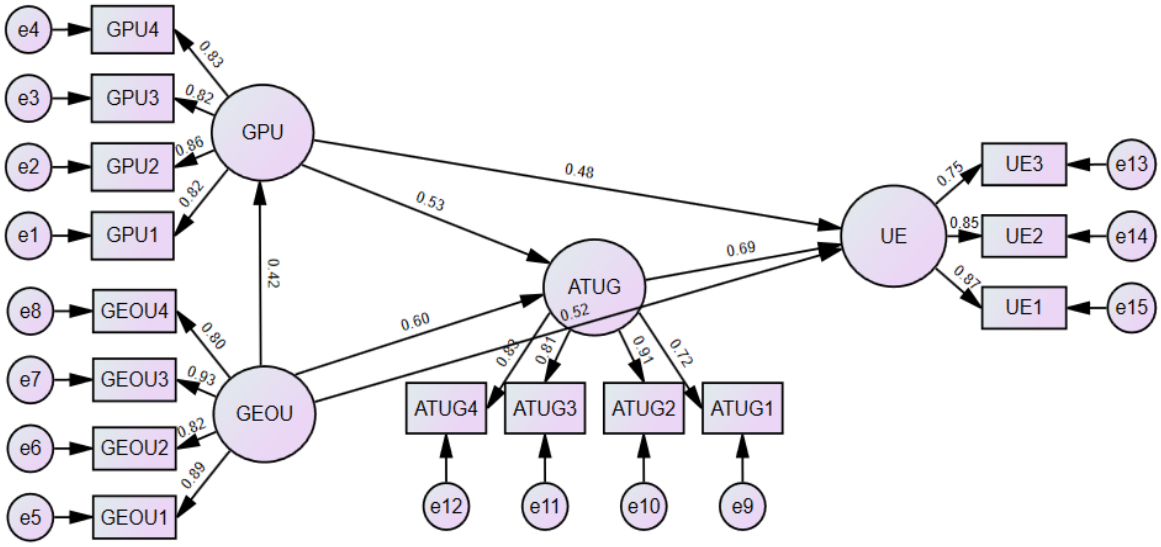


Figure 3. Measurement model

3.4. Hypotheses and testing analysis

This study explored the effect of gamification on user engagement and adherence to COVID-19 preventive measures through the X-GAM framework. Previous research has explored gamification's effect on general health behaviors [19]–[21], but not specifically on sustained engagement with pandemic-related measures. This study seeks to address this gap by examining the influence of ease of use, perceived usefulness, and attitudes toward gamification on adherence to COVID-19 protocols.

The hypothesis testing results, shown in Table 5, indicate that most relationships were supported. H1 confirmed a strong link between ease of use and perceived usefulness ($\beta = 0.746$, $t = 13.677$, $p < 0.001$), suggesting that users find the app more useful when it is easy to use. H2 also confirmed that ease of use positively impacts users' attitudes towards gamification ($\beta = 0.284$, $t = 4.364$, $p < 0.001$). However, H3, which predicted a direct effect of ease of use on engagement ($\beta = 0.096$, $t = 1.297$, $p = 0.194$), was not supported. H4 and H5 showed that perceived usefulness significantly influences both attitudes towards gamification ($\beta = 0.615$, $t = 9.448$, $p < 0.001$) and user engagement ($\beta = 0.424$, $t = 4.812$, $p < 0.001$). Lastly, H6 confirmed a positive relationship between attitude towards gamification and engagement ($\beta = 0.358$, $t = 4.094$, $p < 0.001$).

The results support previous research, highlighting the role of ease of use and perceived usefulness in shaping user attitudes and behavior [33], [41]. This reinforces the need for developers to design applications that users perceive as valuable. By demonstrating that higher perceived usefulness leads to greater engagement, this study supports the idea that users are more inclined to interact with apps that provide clear, tangible benefits. H3, which proposed a direct positive effect of perceived ease of use on engagement, was not supported, diverging from previous research [20], [42]. This inconsistency may be attributed to the prototype nature of the gamified app, suggesting that incomplete features may have hindered user interaction [43]. The study also provides empirical evidence that attitudes toward gamification strongly influence user engagement, as supported by hypotheses H4, H5, and H6. This further strengthens the case for employing gamification in public health apps, as positive attitudes can directly drive sustained interaction. Previous research [44], [45] has also demonstrated that fostering a positive attitude toward gamification enhances engagement, and the present study's results corroborate this relationship.

One of the significant contributions of this study is its validation of the X-GAM within a health intervention framework, offering a practical application for designing gamified public health interventions. By highlighting the influence of perceived ease of use on user engagement, the study reinforces the idea that simplicity in design is crucial for maximizing engagement, a key finding that developers should consider when creating user-friendly apps. Prior studies have similarly emphasized the importance of ease of use in influencing users' perceptions of utility and adoption behaviors [46]. This suggests that future public health apps should focus on minimizing the cognitive load required for users to navigate content, thereby enhancing their overall engagement with preventive measures.

However, the prototype status of the app likely influenced the findings, particularly regarding H3, where incomplete features may have resulted in a suboptimal user experience and lower engagement levels.

Additionally, the study's focus on secondary school students in Sarawak, Malaysia, limits the generalizability of the results to other populations. Future research should aim to test a fully developed version of the app and include a more diverse sample to ensure broader applicability and validate the study's conclusions.

The findings suggest that future public health apps should emphasize user-friendly designs to improve engagement with preventive measures. Researchers should evaluate the impact of a fully developed gamified app to better understand the true role of ease of use in engagement [47]. Broadening the study to encompass diverse age groups and cultural contexts may offer a more complete understanding of gamification's impact. Investigating the long-term effects of gamification on sustained behavior change could also provide crucial insights for developing effective public health strategies.

In conclusion, this study helps explain how gamified interventions can improve user engagement with COVID-19 preventive measures. By validating the X-GAM model within a public health context, the study provides practical insights for designing user-friendly, engaging applications. Although limitations exist, such as the prototype status of the app, this research lays a foundation for future studies aimed at refining gamified strategies to improve compliance with health measures. Addressing these aspects can lead to more effective public health interventions during pandemics and beyond.

Table 5. Research model hypothesis testing results

	Hypothesis	Std.Est	S.E	C.R.	P	Result
H1	GEOU -> GPU	0.746	0.048	13.677	***	Supported
H2	GEOU-> ATUG	0.284	0.062	4.364	***	Supported
H3	GEOU -> UE	0.096	0.076	1.297	0.194	Not supported
H4	GPU -> ATUG	0.615	0.070	9.448	***	Supported
H5	GPU -> UE	0.424	0.102	4.812	***	Supported
H6	ATUG -> UE	0.358	0.095	4.094	***	Supported

Note: Std.Est = Standardized Estimate, S.E = Standard Error, C.R = Critical Ratio Note: ***p < 0.001

5. CONCLUSION

This study adds to existing research by confirming that gamification improves user engagement with public health measures and by combining it with the TAM framework to better understand the factors behind this engagement. Unlike previous research that broadly assessed the impact of gamification, this study narrows the focus to COVID-19 preventive behaviors, offering fresh insights into how game-like elements can influence health-related behavior change. By offering this focused insight, the study plays a key role in creating more effective gamified interventions in public health.

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AUTHOR CONTRIBUTIONS STATEMENT

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Mohd Hazim Kalana	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
Syahrul Nizam Junaini	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Suriati Khartini Jali	✓	✓			✓	✓	✓		✓	✓		✓	✓	✓
Yusep Rosmansyah	✓	✓			✓	✓	✓		✓	✓				✓
Atina Irani Putri	✓	✓			✓	✓	✓		✓	✓				
Ahmad Alif Kamal	✓	✓			✓	✓	✓		✓	✓				✓

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author (SNJ) upon reasonable request.

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