Structural Equation Modeling of Oral Stomatitis and Its Determinants among the Sundanese Ethnic Group: Evidence from IFLS-5

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Abstract: *Background*: Oral stomatitis is an inflammation of the mucosa in various oral structures such as cheeks, gums, tongue, lips, palate, and floor of the mouth that commonly occurs in communities, including among the Sundanese ethnic group. Risk factors affecting stomatitis incidence in the Sundanese population need to be analyzed for developing more effective prevention programs.

Aim: To analyze risk factors for stomatitis among the Sundanese population using panel data from the Indonesian Family Life Survey (IFLS).

Method: This was an analytical observational study using secondary data from IFLS-5. The research design employed structural equation modelling (SEM) analysis examining variables including age, gender, education, residential area classification, general health status, and smoking habits.

Results: The study revealed that age and general health variables had significant associations with stomatitis occurrence (p<0,001). Ages below 25 years and suboptimal health conditions proved to be significant factors influencing increased stomatitis incidence. Meanwhile, gender, education level, residential area classification, and smoking habits showed no significant correlation.

Conclusion: Age and general health status are the main risk factors for stomatitis occurrence among the Sundanese population, which can serve as a reference for prevention program development.

Keywords: Stomatitis, Sundanese, Panel Data, IFLS, Risk Factors, Oral Health.

INTRODUCTION

Oral stomatitis or canker sore, characterized by mucosal inflammation, can arise from various etiologies, including infections, systemic inflammation, and treatment-related factors [1,2]. Effective management is crucial for alleviating symptoms and improving patients' quality of life. The following sections outline key aspects of oral stomatitis and its management. Oral stomatitis can be caused by various microorganisms, including bacteria, viruses, and fungi. Primary infections involve direct invasion, while secondary infections manifest due to systemic conditions [3]. Recurrent Apthous Stomatitis (RAS) is the most common stomatitis linked to systemic inflammation, with elevated systemic immune inflammation index (SII) indicating its role in pathogenesis [4]. Recent studies have explored innovative treatments and the underlying mechanisms associated with canker sores, highlighting the importance of effective management strategies [5].

Canker sores may arise from immune-related disorders, where the body's immune system mistakenly attacks the oral mucosa. Physical injury to the oral cavity, such as biting the cheek or irritation from dental appliances, can trigger ulceration. Deficiencies in vitamins (e.g., B12, folate) and minerals (e.g., iron) are linked to increased susceptibility to canker sores [6]. Poor denture hygiene and fit can lead to Candida colonization, resulting in localized to diffuse mucosal inflammation [5].

The association of oral stomatitis, including canker sores, with various demographic and lifestyle factors is multifaceted. Research indicates that factors such as age, gender, education, residential area classification, general health status, and smoking habits play significant roles in the prevalence and distribution of these oral conditions. The studies reviewed provide insights into how these factors correlate with the occurrence of oral stomatitis. Recurrent aphthous stomatitis (RAS) is prevalent in approximately 20% of the population, with onset typically during adolescence, peaking in adulthood, and decreasing with age [7]. Denture stomatitis is more common in older adults, particularly those aged 51-60 years, and is more prevalent among women [8].

In a study of aphthous ulcers, the highest prevalence was observed in individuals in their second

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decade of life, with a slight female predominance [9]. Higher education levels are associated with better oral health outcomes, including fewer instances of oral stomatitis, as educated individuals are more likely to engage in preventive health behaviors. The impact of residential area classification on oral stomatitis is not directly addressed in the studies, but access to healthcare and socioeconomic factors likely play a role in oral health disparities. Most individuals with RAS are otherwise healthy, although the condition can be associated with systemic diseases like infectious disease, gastrointestinal disease, respiratory disease, cardiovascular disease and Behcet's Disease [7,10]. Self-perceived good health correlates with better oral health outcomes, suggesting that overall health status influences the prevalence of oral conditions. Non-smokers tend to have better oral health, with fewer instances of oral stomatitis, as smoking is a known risk factor for various oral health issues [11,12]. While these studies provide valuable insights, it is important to consider that the pathogenesis of conditions like RAS is complex and multifactorial, involving genetic, nutritional, and possibly infectious components. Additionally, lifestyle factors such as diet and stress, which were not extensively covered in the studies, may also influence the prevalence of oral stomatitis.

The Sundanese have a tradition of eating lalapan that has been going on since the 10th century, which is rooted in the culture and close relationship of the community with nature in the fertile mountainous area. This habit includes the consumption of raw vegetables served with chili sauce and has become an inseparable part of the daily life of the Sundanese people. Along with the development of the era and the use of pesticides in agriculture, concerns have arisen about the negative impact of pesticides on health, especially on vegetables that are consumed raw such as lalapan . Exposure Pesticides on raw vegetables can cause dysbiosis or imbalance oral microbiome that is at risk of triggering various oral health problems. Pesticide compounds that accumulate in oral tissue have the potential to cause inflammation, increasing the risk inflammation, and damage the integrity of the oral epithelial tissue [13]. Sundanese was reported own risk which more tall for experiencing stress compared to other tribes. Prevalence of stress in the Tribe Sundanese reached a fairly high figure (91%). Ethnic group Sun down risk three time more experience stress compared to the Betawi, Javanese, or other ethnics [14].

The Indonesia Family Life Survey (IFLS) is a comprehensive longitudinal survey of socio-economic and health data on an ongoing basis. This survey covers approximately 83% of the Indonesian population spread across 13 provinces since 1993, with data coverage covering the community, household, and individual levels [15]. Data from IFLS had been used structural equation modelling to analyze the complex relationship between toothache and its associated factors among children [16] and analyze the risk factors of oral stomatitis among Malay ethnic group [17].

In the context of public health research, SEM offers significant advantages over traditional statistical approaches such as logistic regression. Unlike conventional methods that typically examine direct relationships between observed variables, SEM allows researchers to simultaneously model complex relationships, including direct, indirect, and mediating effects among multiple variables. This is particularly valuable when investigating multifactorial health outcomes, such as those influenced by behavioral, environmental, and psychosocial determinants of oral health [16].State of the art need to be performed to analyze the associated risk factors based on IFLS including age, gender, education level, residential area classification, health general, and smoke habit among Sundanese ethnic group.

METHODS

The study analyzed the risk factors of Stomatitis among Sundanese ethnic group from the secondary data obtained of the Indonesian Family Life Survey (IFLS-5) 2014–2015. The subjects were 3,873. The survey collected individual, family, and community level. The subjects were from Sunda ethnic group by aged >14 year.

The main variable analyzed was whether the subject had experienced an oral stomatitis in the past four weeks, based on the IFLS survey question: “Did you experience oral stomatitis/canker sore in the last four weeks?”

Additional factors believed to be linked to oral stomatitis included the child’s age, gender, place of residence (urban or rural), socioeconomic status (based on parental income), smoking habits, dietary habits, race/ethnicity, and frequency of tooth brushing. Age, sex, and ethnicity were treated as potential confounders.

To assess tooth brushing habits, the survey asked: “When do you brush your teeth?”, with the following response options: (A) in the morning, (B) at night, (C) in the afternoon, (D) after meals, (E) never, and (F) don’t know.

The data was analyzed using SEM (structural equation modelling) of criterion variable of oral stomatitis results (no = 0, yes = 1). The authors

categorized independent variables in accordance with the proposed hypothesis.

The predictors used include: Age (< 25 years = 0), (25–40 years = 1), (41–55 years = 2), (56–70 years = 3), and (>70 years = 4), Gender (male = 1, and female = 0), Classification of residential area (rural = 1, and urban = 0), Level education (no schooling = 0, primary education = 1, secondary education = 2, and higher education = 3), Smoking habits (do not smoke = 0, light (< 10 sticks/day) = 1, medium (10–20 bars/day) = 2, heavy (>20 bars/day) = 3), As well as health general (Healthy = 1, and no healthy = 0).

IFLS data on risk factors for oral stomatitis in Sundanese people were analyzed. Use software STATUS, temporary connection multifaceted analyzed use SEM. After data collected, the multivariate analysis using the SMART-PLS program.

According to the book “SmartPLS Applications For Beginner Statistician”, to conduct data analysis, the researcher conducted descriptive analysis aims to provide a general overview of sample characteristics and variable distribution. Data analysis was performed using Structural Equation Modeling Partial Least Squares (SEM-PLS) method.

1. EVALUATION OF MEASUREMENT MODEL (OUTER MODEL)

Test Validity Convergence

Convergence validity rated based on correlation between Items score / compound score with construct score calculated using PLS. The size reflect the significant correlation (>0.60) with measured constructs.

In addition, the convergent validity value can also be measured with Average Variance Extracted (AVE) every construct in model. If AVE > 0.5 means considered valid.

Test Validity Discriminant

One method to assess validity is by examining the cross-loading values. A useful approach to evaluate whether a construct demonstrates adequate discriminant validity is to compare its loading values. Specifically, the loading on the intended construct should be significantly higher than its loadings on other constructs. Additionally, the Fornell-Larcker criterion can be used, which involves comparing the square root of the Average Variance Extracted (AVE) for each construct with the correlations between that construct and others in the model. If the square root of the AVE for a construct is greater than its correlations with other constructs, then it can be considered to have good discriminant validity.

Reliability Test

In addition to testing construct validity, a reliability assessment was also conducted. This was measured using composite reliability and Cronbach's alpha based on the set of indicators representing the construct. A construct is considered reliable if its composite reliability and Cronbach's alpha values both exceed 0.70.

2. EVALUATION MODEL STRUCTURAL (INNER MODEL)

Coefficient Determination (R Square)

The R Square value represents the coefficient of determination for an endogenous construct. Generally, R Square values are interpreted as follows:0.67 indicates a strong effect, 0.33 a moderate effect, and 0.19 a weak effect. The adjusted R Square is used to show the extent to which independent variables explain the variation in the dependent variable. Changes in R Square values can be used to assess whether a particular latent independent variable has a meaningful influence on a latent dependent variable.

3. Testing Hypothesis

Hypotheses were tested using the Bootstrapping method in Smart-PLS to determine the significance of relationships within the model. The resulting output includes path coefficients, t-statistics, and p-values for each path in the structural model.

Path coefficients indicate the direction and strength of the relationship between variables, ranging from -1 to 1. A coefficient between 0 and 1 signifies a positive relationship, while one between -1 and 0 indicates a negative relationship. These values can be found in the "original sample" column of the hypothesis testing results table.

If the path coefficient is positive, it suggests that the influencing variable affects the dependent variable in the same direction. Conversely, a negative coefficient implies an inverse relationship.

T-statistics are used to evaluate the statistical significance of relationships between variables. A t-value greater than 1.96 indicates a significant relationship. Additionally, the p-value reflects statistical significance; a p-value less than 0.005 means the null hypothesis can be rejected, confirming a significant relationship between the variables.

RESULTS

This study was conducted on 3,872 respondents obtained from secondary data from the Indonesian Family Life Survey (IFLS) to analyze risk factors for stomatitis in the Sundanese people.

According to the data in the table above, out of 3,872 Sundanese respondents, the majority were female—2,111 individuals (54.5%)—while males accounted for 1,761 individuals (45.5%). In terms of age distribution, the largest group was aged 25–40 years, comprising 1,506 respondents (38.9%). This was followed by those aged 41–55 years with 944 respondents (24.4%), under 25 years with 900 respondents (23.2%), 56–70 years with 419 respondents (10.8%), and over 70 years with 103 respondents (2.7%). Regarding education, most participants had completed secondary education, totaling 2,132 individuals (55.1%). This was followed by 1,336 individuals (34.5%) with primary education, and 404 individuals (10.4%) with higher education. There were no respondents who had never attended school.

When looking at residence, the majority lived in urban areas2,650 individuals (68.4%) while 1,222 respondents (31.6%) resided in rural areas. In terms of general health, 2,962 respondents (76.5%) reported being in good health, while 910 (23.5%) reported otherwise. As for smoking habits, most respondents2,539 (65.6%)did not smoke. Meanwhile, 667 (17.2%) were moderate smokers, 548 (14.2%) were light smokers, and 118 (3.0%) were heavy smokers. Regarding stomatitis, 3,081 respondents (79.6%) reported not having the condition, while 791 (20.4%) reported experiencing it.

The relationship that has two stars (★★) indicates significant correlation (p <0.001), such as age, and general health, which shows a strong influence on stomatitis. Meanwhile, the relationship with the sign (✖), such as education level, smoking habits,

Table 1: Prevalence of oral stomatitis for each outcome variables

Outcome variable	Sundanese people, N= 3872		
	N	Prevalence of oral stomatitis (%)	Confidence Interval (95%)
Age (years)			
<25	900	23.2	1.28-1.34
25-40	1506	38.9	
41-55	944	24.4	
56-70	419	10.8	
>70	103	2.7	
Gender			
Woman	2111	54.5	0.44-0.47
Man	1761	45.5	
Level of education			
Not attending school	0	0	1.74-1.78
Basic education	1336	34.5	
Secondary education	2132	55.1	
Higher education	404	10.4	
Urban	2650	68.4	0.30-0.33
Rural	1222	31.6	
General Health			
Not healthy	910	23.5	0.75-0.78
Healthy	2962	76.5	
Smoking Habit			
Do not smoke	2539	65.6	0.55-0.61
Light smoker	548	14.2	
Moderate smoker	667	17.2	
Heavy smoker	118	3.0	
No	3081	79.6	
Yes	791	20.4	

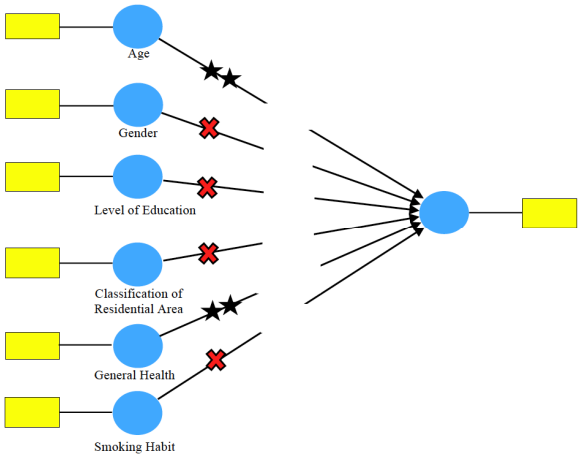

Figure 1: Structural equation model of oral stomatitis and its associated factors.

Description: ★★ = ($p < 0.001$) significant, ★= ($p < 0.005$) significant, ✖ = ($p > 0.005$) not significant.

residential classification, and gender, shows that although there is a direction of the relationship, the effect is not statistically significant. This shows that only a few variables have a significant impact on the incidence of Stomatitis.

EVALUATION OF MEASUREMENT MODEL (OUTER MODEL)

1. Convergent Validity

The table below is the result of outer loading calculation using Smart PLS program . An indicator is said to be valid if the outer loading value ≥ 0.7. So it can be seen in the table that none of the indicator values are less than 0.7.

2. Discriminant validity

The table below shows the cross loading factor values which are useful for determining whether a construct has adequate discriminant, namely by comparing the loading values on the intended construct which must be greater than the loading values on other constructs.

3. Reliability Test

The table below is a reliability test. constructs measured by composite reliability and Cronbach's alpha from the indicator blocks that measure the construct . A construct is declared reliable if it has a composite reliability value. above 0.70 and cronbach's alpha above 0.70.

Structural Model Evaluation (Inner Model)

1. R Square (R^2)

The R-Square value has three criteria, namely values > 0.75 (strong), > 0.50 (medium) and > 0.25 (weak). The assessment of the structural model can be evaluated using the Smart PLS program by considering the R^2 value for each endogenous latent variable as the predictive power of the structural model. The results of R^2 indicate the number of variants of the construct explained by the model.

Based on the test results, stomatitis is influenced by gender, smoking habits, general health, education level, age and classification of residential area by 1.5%. While the remaining 98.5% is influenced by other variables that are not included in the research model.

Hypothesis Testing

Hypothesis testing can be done with Path Coefficient then bootstrapping is done in smartPLS 3.0. A hypothesis will be accepted if the two-tailed significance test and margin of error have a value of 0.005 in testing the research hypothesis. The requirements that must be met in conducting the test are the t-statistics value> 1.96 and p-values <0.005 in order to be said to be significant or accepted.

After the R-Square calculation is done, the model evaluation is done by looking at the significance value to determine the influence between variables with the bootstrapping method. The calculation results can be seen in the following table.

Hypothesis test (H1) show that the effect of age on stomatitis shows a path coefficient value of -0.096 with a t-statistic value of 6.057 and p<0.001. These results indicate that age has a negative and significant effect on stomatitis, which means that the first hypothesis can be accepted. The results of the second hypothesis test (H2) show that the effect of gender on stomatitis shows a path coefficient value of -0.005 with a t-statistic value of 0.221 and a p-value of 0.825. These results indicate that gender has a negative but insignificant effect on stomatitis, which means that the second hypothesis is rejected. The results of the third hypothesis test (H3)

Table 2: Convergent Validity

Variables	Indicator	Loading Factor Value	Information
US	Age	1,000	Valid
JK	Gender	1,000	Valid
TP	Level of education	1,000	Valid
RA	Classification of Residence	1,000	Valid
MY	General Health	1,000	Valid
KM	Smoking Habit	1,000	Valid
STO	Stomatitis	1,000	Valid

Table 3: Discriminant Validity

	JK	KM	MY	RA	STO	TP	US
Gender	1,000						
Habit Smoke	0.658	1,000					
General Health	0.043	0.026	1,000				
Classification Residence	0.004	0.030	-0.009	1,000			
Stomatitis	-0.036	-0.055	-0.055	-0.008	1,000		
Level of education	0.051	-0.041	0.134	-0.237	0.026	1,000	
Age	-0.006	0.064	-0.202	0.031	-0.086	-0.279	1,000

Table 4: Reliability Test

Variables	Cronbach's Alpha	Reliability Composite
Age	1,000	1,000
Gender	1,000	1,000
Level of education	1,000	1,000
Classification of Residences	1,000	1,000
General Health	1,000	1,000
Smoking Habit	1,000	1,000
Stomatitis	1,000	1,000

Table 5: Hypothesis Testing

	Original Sample (O)	Sample Average	Standard Deviation	T Statistics	P Values
Age -> Stomatitis	-0.096	-0.096	0.016	6,057	0,000
Gender -> Stomatitis	-0.005	-0.005	0.022	0.221	0.825
Education Level -> Stomatitis	0.007	0.008	0.016	0.448	0.654
Classification of Residence -> Stomatitis	-0.002	-0.002	0.016	0.159	0.874
General Health -> Stomatitis	-0.074	-0.074	0.017	4,309	0,000
Smoking Habit -> Stomatitis	-0.044	-0.044	0.021	2,071	0.039

show that the effect of education level on stomatitis shows a path coefficient value of 0.007 with a t-statistic value of 0.448 and a p-value of 0.654. These results indicate that education level has a positive but insignificant effect on stomatitis, which means that the third hypothesis is rejected. The results of the fourth

hypothesis test (H4) show that the effect of residential classification on stomatitis shows a path coefficient value of -0.002 with a t-statistic value of 0.159 and a p-value of 0.874. These results indicate that residential classification has a negative but insignificant effect on stomatitis, which means that the fourth hypothesis is rejected. The results of the fifth hypothesis test (H5) show that the effect of general health on stomatitis shows a path coefficient value of -0.074 with a t-statistic value of 4.309 and $p<0.001$. These results indicate that general health has a negative and significant effect on stomatitis, which means that the fifth hypothesis is accepted. The results of the sixth hypothesis test (H6) show that the effect of smoking habits on stomatitis shows a path coefficient value of -0.044 with a t-statistic value of 2.071 and a p-value of 0.039. These results indicate that smoking habits have a negative but insignificant effect on stomatitis, which means that the sixth hypothesis is rejected.

DISCUSSION

The findings of the study indicate that several risk factors associate with the occurrence of stomatitis in the Sundanese population, each with varying levels of association. Analysis results showed that age has a negative and statistically significant impact on stomatitis, meaning that as individuals grow older, the likelihood or severity of stomatitis tends to decrease. This aligns with previous study, which reported that the frequency of stomatitis cases generally declines with age due to increased awareness and better oral hygiene practices [18]. The highest rate of stomatitis was observed in the 25–40 year age group, suggesting that individuals in their productive years are more prone to stomatitis, supporting studies that identified the 20–30year age range as particularly susceptible [19,20].

In this study, male exhibited fewer cases of stomatitis than women. It might because of male experience more stable hormone levels, unlike women, who may face hormonal fluctuations such as a drop in progesterone during the luteal phase of the menstrual cycle. Previous study supported this hormonal link to stomatitis, although in this case, the association was not strong enough to be considered significant [21,22]. The education level had no correlation with oral stomatitis. The higher educational attainment may face a slight higher risk of stomatitis. This is supported by studies that report college students often experience greater levels of stress due to academic pressures, including exams and assignments, which may increase their susceptibility to stomatitis [17,23].

The place of residence had insignificant correlation with oral stomatitis. The result also suggests a possible trend where individuals living in rural areas may be at lower risk of developing stomatitis compared to those in urban settings. This result is consistent with previous studies, which highlight that urban lifestyle characterized by stress, poor dietary habits, and environmental exposures may contribute to the increased incidence of stomatitis [23]. The general health status had a negative and statistically significant association on the occurrence of stomatitis. This means individuals with better overall health were less likely to experience stomatitis compared to those with poorer health. In this study, smokers were found to have a lower incidence of stomatitis compared to non-smokers. Similar findings were reported in prior research, which noted a reduced prevalence of stomatitis among tobacco users [24-26] and supported the finding related association between general health condition with oral stomatitis among Malay ethnic group using IFLS-5 based data [17].

The measurement model (outer model) evaluation using the SmartPLS software reported all indicators fulfil the required validity and reliability criteria. The convergent validity analysis shows that each indicator has an outer loading value of 0.7 or higher, confirming that all indicators effectively measure their respective constructs. Additionally, the discriminant validity test results are favorable, indicating that each indicator loads more strongly on its intended construct than on others, demonstrating good construct discrimination. Furthermore, the reliability assessment reveals that all constructs have composite reliability and Cronbach's alpha values above 0.70, indicating that the constructs used in the study are both reliable and consistent for measuring the examined concepts. Therefore, the measurement model used in this research is considered valid and reliable for evaluating the relationships between the variables.

Regarding the structural model (inner model) evaluation using SmartPLS, the R-Square value is 0.015 or 1.5%. This means that the variables gender, smoking habits, general health, education level, age, and residential area classification account for only 1.5% of the variation in stomatitis incidence, with the remaining 98.5% influenced by factors outside the current model. Hypothesis testing revealed that the relationships between gender, smoking habits, residential area, and education level with stomatitis were statistically insignificant, leading to the rejection of these hypotheses. These findings align with previous studies suggesting that gender, education level, and residence classification are not significantly linked to stomatitis occurrence. Overall, these findings indicate the need to pay attention to other variables outside the model that may have a significant contribution to the incidence of stomatitis.

Despite the development of a structural model to investigate the incidence of stomatitis, the model was only able to account for 1.5% of the observed variation. This highlights a significant limitation in the model's explanatory power and suggests that key contributing variables may have been omitted. It is crucial to acknowledge this limitation explicitly, as it underscores the need for a more comprehensive approach in future research. Several factors that were not included in the current analysissuch as dietary patterns, oral hygiene practices, stress levels, and exposure to environmental agents like pesticidesmay play an important role in the development of stomatitis. Incorporating these variables in future models may enhance predictive accuracy and provide a more nuanced understanding of the multifactorial etiology of stomatitis. This would ultimately support more targeted preventive strategies and clinical interventions.

The current study presents an initial exploration of factors affecting oral health among the Sundanese population. While the discussion has insightfully highlighted the potential roles of traditional dietary patternssuch as the consumption of lalapanand pesticide exposure [13], these variables were not included in the structural equation model (SEM). This omission limits the model's ability to fully capture the socio-environmental context influencing oral health outcomes. Future models should aim to incorporate these factors, potentially as latent constructs, to better reflect their indirect or multifactorial impact. Additionally, stress represents another important variable with high relevance in this population. Given its known association with both general and oral health, stress could be modeled as a latent or mediating variable in future analyses. At the very least, its exclusion and potential indirect effects should be explicitly addressed in the limitations section. Incorporating such culturally and contextually relevant variables would enhance the explanatory power and ecological validity of future models.

CONCLUSION

This study concludes that among the Sundanese population, age and general health conditions are significantly associated with the incidence of stomatitis. As individuals age and maintain better overall health, their risk of developing stomatitis decreases. Although other factors such as gender, education level, smoking habits, and place of residence showed trends or patterns, their relationships with stomatitis were statistically insignificant. Notably, individuals in their productive years (25–40 years) showed higher susceptibility, likely due to lifestyle and stress-related factors. While smokers and rural residents exhibited a lower prevalence of stomatitis, these trends lacked statistical strength. The evaluation of the measurement model confirmed that the constructs used were both valid and reliable. However, the structural model revealed a low explanatory power (R^2 = 1.5%), indicating that the variables in this study account for only a small portion of the variance in stomatitis incidence. Therefore, future research should explore additional variables that may play a more substantial role in the development of stomatitis.

ETHICS

All research procedures were thoroughly reviewed and received approval from the institutional review boards (IRBs) in both the United States and Indonesia, specifically at Gadjah Mada University. Informed consent was obtained from the parents and legally authorized representatives of participants who were illiterate. Consent was secured prior to the commencement of fieldwork. Additionally, assurances of participant anonymity and confidentiality were established before the survey began. All procedures followed the ethical principles outlined in the Declaration of Helsinki.

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Received on 12-05-2025 Accepted on 09-06-2025 Published on 10-07-2025

https://doi.org/10.6000/1929-6029.2025.14.34