

Determinant Factors of Obesity Among Junior High School Adolescents Using a Social Ecological Model Approach

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Abstract

Background: Adolescent obesity is a growing global public health challenge associated with adverse physical, psychological, and metabolic outcomes. The Social Ecological Model (SEM) provides a comprehensive framework for understanding obesity through individual, interpersonal, organizational, community, and societal factors. However, evidence on the mediating role of school health programs remains limited, particularly in developing countries.

Objective: This study examined associations between SEM dimensions and adolescent obesity and investigated the mediating role of the School Health Program (UKS) in Indonesia.

Methods: A cross-sectional study was conducted among 292 junior high school students in Banyuwangi Regency, Indonesia. Five dimensions of the SEM the microsystem, mesosystem, exosystem, macrosystem, and chronosystem of UKS implementation and obesity status were assessed. Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) to evaluate direct and indirect relationships.

Results: All of the SEM dimensions were significantly associated with UKS implementation ($p < 0.05$). Among the ecological dimensions, only the exosystem was significantly associated with adolescent obesity ($\beta = 0.245$, $p = 0.003$). The microsystem, mesosystem, macrosystem, and chronosystem showed no significant associations (all $p > 0.05$). UKS implementation was not significantly associated with adolescent obesity ($\beta = -0.061$, $p = 0.421$) and did not mediate relationships between any SEM dimension and obesity (all indirect effects, $p > 0.05$). These findings suggest that socioeconomic and environmental conditions beyond the immediate school setting may exert greater influence on adolescent obesity than current school-based health programs.

Conclusions: Adolescent obesity prevention requires multilevel interventions extending beyond conventional school health programs. Strengthening collaboration among schools, families, healthcare providers, communities, and policymakers is essential to address broader ecological determinants and improve obesity prevention strategies.

Key Words: Adolescent Obesity; Social Ecological Model; School Health Program.

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1- INTRODUCTION

Obesity in adolescents is one of the public health issues that continues to rise in various countries. Adolescence is marked by rapid growth and development, leading to increased energy and nutrient needs to support body tissue formation (1). However, lifestyle changes characterized by increased consumption of high-calorie, sugary, salty, and fatty foods, along with low physical activity, lead to an energy imbalance that increases the risk of overweight and obesity (2). This condition is associated with an increased risk of non-communicable diseases, including type 2 diabetes mellitus, hypertension, metabolic disorders, as well as psychological issues, including depression and low self-esteem (2). In Indonesia, the issue becomes even more complex due to the triple burden of malnutrition, which includes the simultaneous presence of undernutrition, micronutrient deficiencies, and overnutrition, influenced by the imbalance in the food system, changes in consumption patterns, and social-environmental factors (3).

Data from the 2023 Indonesian Health Survey (*Survei Kesehatan Indonesia*) reveals that the prevalence of overweight and obesity among adolescents reached 19.7%, indicating that nearly one in five adolescents in Indonesia experiences excess body weight issues (4). A similar trend is observed at the provincial level in East Java, with an obesity prevalence of 15% in the 13–15 age group and 10.2% in the 16–18 age group. The situation in Banyuwangi Regency is particularly alarming, where school health screening reports conducted by local *Puskesmas* (2023–2024) indicated that approximately 46% of adolescents were identified as obese. This alarming local figure highlights early adolescence (ages 10–14 years, corresponding to junior high school level) as a critical window of vulnerability. Consequently, obesity has become a

pressing public health priority in Banyuwangi, requiring evidence-based prevention strategies involving families, schools, and social environments.

To date, most efforts to prevent and control obesity have focused on changing individual behaviors through education and awareness-raising initiatives that promote healthier lifestyles (5). However, various studies show that approaches that only target individual factors have not been able to provide a sustainable impact on reducing the prevalence of obesity (6). This is because adolescents' eating behaviors and physical activities are influenced by various interacting factors, ranging from individual characteristics, family, school environment, socio-economic conditions, to the broader social environment. Therefore, this study uses the Social Ecological Model (SEM) as a conceptual framework to analyze the determinants of obesity at various levels, namely the microsystem, mesosystem, exosystem, macrosystem, and chronosystem (7). This approach enables a more comprehensive identification of the factors contributing to obesity than an approach that focuses solely on individual behavior.

As part of the SEM approach, schools are environments that play a crucial role in shaping adolescent health behaviors because students spend most of their time in the school environment (8). In Indonesia, the School Health Program (UKS) is a school-based health program that integrates health education, health services, and the development of a healthy school environment. Through this approach, the UKS has the potential to support obesity prevention efforts by fostering healthy living behaviors and creating a supportive school environment (9). However, the effectiveness of the implementation of the UKS is still influenced by various socio-ecological determinants, including family support,

school culture, socio-economic conditions, and the community environment. Although school-based nutrition education has been proven to increase knowledge and improve the eating behavior of adolescents (10), implementing the UKS in a way that integrates multiple determinants of obesity remains a challenge.

Research on adolescent obesity in Indonesia generally still focuses on individual factors and has not extensively examined the interactions of various determinants at each level of the Social Ecological Model or the role of the UKS as a mechanism that connects these factors with the occurrence of obesity. As a result,

scientific evidence regarding the role of the UKS as a mediating variable in the relationship between social ecological determinants and adolescent obesity is still limited, especially at the regional level. Therefore, this study aims to analyze the determinants of obesity occurrence in adolescents using the Social Ecological Model approach and to evaluate the role of the implementation of UKS as a mediating variable. The results of this study are expected to provide scientific evidence for the development of more comprehensive, integrated, and sustainable school-based obesity prevention policies and programs (Figure 1).

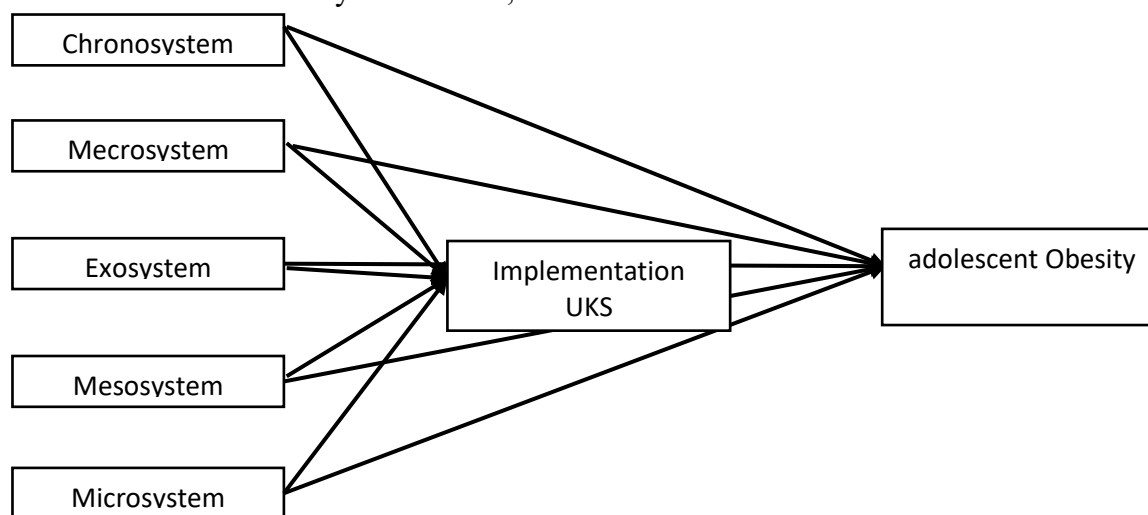


Figure-1: The conceptual model of the research.

2- MATERIALS AND METHODS

2-1. Study Design and Settings

This study employed an analytical descriptive design with a cross-sectional approach. The study population comprised 1,219 junior high school students identified as obese based on nutritional status screening reports across 10 schools within three Puskesmas (Primary Health Center) working areas in Banyuwangi Regency. Based on the Cochran formula with finite population correction, a target sample size of 292 respondents was determined (11).

Participants were selected using a multistage sampling procedure that

combined purposive sampling with proportionate stratified random sampling. Initially, three Puskesmas working areas (Mojopanggung, Songgon, and Siliragung) were selected purposively based on having the highest prevalence of adolescent obesity. Sample allocation across strata was determined proportionally using the formula $n_h = (N_h / N) \cdot n$, resulting in 171 respondents from Mojopanggung, 67 from Songgon, and 54 from Siliragung. The sample quota was distributed across 10 target schools within the working areas of three Puskesmas: Mojopanggung (57, 57, 57), Songgon (23, 22, 22), and Siliragung (14, 14, 13, 13). Within each school, eligible students meeting the inclusion and

exclusion criteria were selected through simple random sampling with school administration facilitation. Informed consent was obtained from all participants and their guardians prior to data collection.

2-2. Measurement

As presented in Table 1, the data collection instruments in this study comprised physical measurements and structured questionnaires. The first part collected sociodemographic information from the respondents, including age, gender, parental occupation, parental income, and parental education.

To determine nutritional status, anthropometric data were objectively measured by trained enumerators; no self-reported anthropometric data were utilized in this study. Body weight was measured to the nearest 0.1 kg using a calibrated digital floor scale with a capacity of up to 150 kg. Body height was measured to the nearest 0.1 cm using a portable stadiometer (microtoise) with a maximum range of 200 cm. The subject stood upright with the head facing straight ahead, neither tilted downward nor backward. All equipment fully complied with the technical specifications and medical device standards set by the Ministry of Health of the Republic of Indonesia (Kemenkes RI) (12). Participants were measured in light clothing and without footwear. To ensure measurement precision, duplicate measurements were performed for all participants, and the average value of the two readings was used for analysis. Prior to field data collection, all enumerators completed standardization training, and inter-observer reliability was evaluated using the Technical Error of Measurement (%TEM) to ensure high consistency across observers (%TEM < 1.5% for height and < 1.0% for weight). Obesity status was defined using the World Health Organization (WHO) Growth Reference for children and adolescents aged 5–19

years, classified as a Body Mass Index-for-age Z-score (BAZ) > +2 SD (13). The second part comprised questionnaire instruments measuring ecological system constructs, including the chronosystem, macrosystem, exosystem, mesosystem, and microsystem, as well as the implementation of the UKS. This study utilized the validated Indonesian version of the instrument (14–17).

2-3. Data Analysis

Data collection involved editing, coding, and entering the data from the completed questionnaires into Microsoft Excel. The data were then analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) software, including assessments of the outer and inner models. Mediation effects were evaluated using the bootstrapping procedure in PLS-SEM. Given the cross-sectional nature of the data, the analysis assesses statistical associations among variables rather than establishing temporal causal relationships.

The research procedure consisted of problem formulation, development of the theoretical and conceptual framework, participant recruitment, data collection, data analysis, and formulation of conclusions and recommendations. Next, the researcher developed the theoretical and conceptual framework based on the social-ecological model. The research method used was quantitative with a cross-sectional design, where the sample consisted of 292 obese adolescents. Data collection was conducted using a questionnaire instrument that included independent variables (social ecology), mediating variables (Implementation of UKS), and dependent variables (adolescent Obesity), as well as respondent characteristics. The collected data were then analyzed and presented using the PLS-SEM method before conclusions and research recommendations were drawn.

2-4. Ethical Considerations

This study was approved by the Health Research Ethics Committee (KEPK) of the Faculty of Nursing, Universitas Jember (No. 494/UN25.1.14/KEPK/2025). Prior to data collection, a two-tiered consent process was systematically executed. First, written parental consent, along with an information sheet outlining the study's purpose, anthropometric procedures, data confidentiality, and voluntary nature, was distributed to parents or legal guardians via homeroom teachers. Parents who agreed signed and returned the consent form. Second, written adolescent assent was obtained from all eligible students aged 10–14 years after providing an age-appropriate explanation of the study. Participants were explicitly informed that participation was entirely voluntary and

that declining or withdrawing at any stage would not affect their academic standing or access to school health services.

3- RESULTS

The study was conducted in 10 junior high schools selected based on students' nutritional status data, UKS program implementation, and regional representation. The total number of respondents was 292, with the following results (Table 2). The respondent characteristic analysis shows that a majority of the respondents are female (62%). The age of the respondents is predominantly in the early adolescence category of 10–14 years (80.5%), which aligns with the standard age structure of junior high school students (Grades 7 to 9) in Indonesia and conforms to the global definition of early adolescence (18).

Table-1. Results of the validity and reliability test of the research instrument.

Instrument	Item	Validity Result	Reliability Result	Interpretation
Food School Environment	22	All items are valid, with a calculated r value > the table r value for all items.	Cronbach's $\alpha=0.61-0.74$	Validity & reliability of the instrument are good for measuring the school canteen environment.
Adolescent Sedentary Activity Questionnaire (ASAQ)	12	All items are valid, with a calculated r value > the Table r value for all items.	Reliability score 0.57-0.86	Valid and reliable instruments, suitable for measuring sedentary activity
Family Influence Scale (FAS)	6	All items are valid, with a calculated r value > table r value for all items.	Cronbach's Alpha = 0.64	Valid and reliable instruments for measuring family socioeconomic status
Parental Feeding Style	17	The calculated r value > table r value for 17 out of 30 items	Cronbach's $\alpha=0.828$	Good reliability of valid and reliable instruments for parental parenting style
Dutch Eating Behaviour Questionnaire (DEBQ)	33	Validity test with a calculated value greater than 0.444.	Cronbach's $\alpha=0.88$	Good construct validity; high reliability of valid and reliable instruments for adolescent eating habits
Implementation of the School Health Program	17	The calculated r value > table r value for 17 out of 19 items.	Cronbach's $\alpha=0.906$	Valid and reliable instruments for measuring the implementation of UKS in schools
Adolescent Obesity	Open questions (BB, TB, BMI/Z-Score)			

The BMI-for-age Z-score assessment indicated that 64.4% of the respondents (188 students) were classified as obese. This high proportion is strongly linked to the socioeconomic profile of the respondents' families, where 54.1% of parents earned below the regional minimum wage and 42.1% had a basic-to-intermediate education level. As **Table-2**. Characteristics of the respondents.

Characteristics of Adolescents	Category	n	%
Gender	Male	111	38.0
	Female	181	62.0
Age	Early adolescence (10-14 years)	235	80.5
	Late adolescence (15-19 years)	57	19.4
BMI (Z-Score)	Overnutrition (+1SD to +2SD)	104	35.6
	Obesity (> +2SD)	188	64.4
Parents' Occupation	Civil Servant	58	19.9
	Entrepreneur	114	39
	Business Owner	32	11
	Farmer	15	5.1
	Other	73	25
Income (Monthly)	< UMR (Rp 2.638.628)	158	54.1
	>UMR (Rp 2.638.628)	134	45.9
Parents' Education	Elementary – Junior High School	123	42.1
	Senior High School	74	25.3
	Higher Education	95	32.5

3-1. Outer Model Test

3-1-1.Validity Test

The results of the second outer loading test show that most indicators have values above 0.70 (Table 3). However, the indicator for adolescent obesity occurrence variables (Z) that have an outerloading value of 1.000. This value occurs because the variable is measured using a single indicator, namely BMI/Z-score. In PLS-SEM analysis, constructs with single indicators will yield a loading value of 1.000 because the indicator directly represents the construct (21). Therefore, convergent validity evaluations such as AVE and composite reliability are not conducted on this variable.

3-1-2. Reliability Test

In Table 4, the reliability test shows that all research variables have met

highlighted in recent literature, lower household income and lower parental educational background often constrain families to low-cost, energy-dense processed foods, while early adolescents simultaneously gain greater autonomy in purchasing unhealthy snacks around the school environment (19, 20).

the established reliability criteria. Cronbach's alpha and both composite reliability measures (rho_A and rho_C) exceeded the minimum threshold of 0.60, indicating that each construct has an adequate level of reliability in measuring the latent variables. Furthermore, the average variance extracted (AVE) values for all variables are above 0.50.

The variable of obesity incidence is modeled as a single-indicator construct measured using one indicator, namely the Body Mass Index according to Age (BMI/A) Z-score, a standard measurement recommended by the WHO and the Ministry of Health to assess adolescent obesity status, with the validity of the measurement based on the conceptual validity of the indicator (21,22).

Table-3. Outer model analysis.

Variable / Dimension	(Chronosystem) (X1)	(Macrosystem) (X2)	(Exosystem) (X3)	(Mesosystem) (X4)	(Microsystem) (X5)	Implementation of UKS (Y)	Obesity Incidence (Z)
X1.1	0.869						
X1.2	0.895						
X1.3	0.887						
X1.4	0.871						
X2.2		0.741					
X2.3		0.781					
X2.4		0.782					
X2.5		0.785					
X3.1			0.880				
X3.2			0.877				
X3.3			0.741				
X4.1				0.890			
X4.2				0.913			
X4.3				0.889			
X4.4				0.888			
X5.1					0.889		
X5.2					0.910		
X5.3					0.901		
Y1						0.916	
Y2						0.902	
Y3						0.908	
Z							1.000

Table-4. Reliability test table.

Variabel	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)	Ket
X1	0.904	0.911	0.932	0.775	Reliabel
X2	0.775	0.778	0.855	0.596	Reliabel
X3	0.782	0.805	0.873	0.697	Reliabel
X4	0.917	0.922	0.941	0.801	Reliabel
X5	0.883	0.888	0.928	0.810	Reliabel
Y	0.895	0.896	0.934	0.826	Reliabel

3-1-3. Discriminant Validity

As shown in Table 5, the loading values on the indicators of variables X1, X2, X3, X4, X5, Y, and Z show a consistent pattern, where the correlation of the indicators with their main construct is always higher than their correlation with other constructs. Thus, the criteria for cross-loading-based discriminant validity

have been met. Specifically, for variable Z (adolescent obesity), its indicator has the highest absolute value on its own construct, which is 1.000. Although this variable technically meets the criteria for discriminant validity, its interpretation becomes quite limited because the variable is Evaluasi model struktural (*inner model*) measured using a single-item construct.

Table 5. Cross-loading result.

	X1	X2	X3	X4	X5	Y	Z
X1.1	0.869	0.183	0.126	0.121	0.324	0.305	-0.050
X1.2	0.895	0.212	0.196	0.175	0.373	0.408	-0.022
X1.3	0.887	0.222	0.151	0.178	0.361	0.360	-0.007
X1.4	0.871	0.223	0.126	0.151	0.338	0.323	0.028
X2.2	0.188	0.741	0.180	0.100	0.132	0.312	-0.036
X2.3	0.172	0.781	0.044	0.143	0.243	0.339	-0.003
X2.4	0.159	0.782	0.087	0.158	0.133	0.319	0.060
X2.5	0.203	0.785	0.084	0.133	0.167	0.378	-0.008
X3.1	0.175	0.099	0.880	0.244	0.185	0.337	0.001
X3.2	0.163	0.091	0.877	0.257	0.165	0.316	-0.041
X3.3	0.080	0.099	0.741	0.201	0.106	0.237	0.064
X4.1	0.184	0.183	0.301	0.890	0.317	0.411	-0.001
X4.2	0.139	0.155	0.273	0.913	0.272	0.364	-0.017
X4.3	0.159	0.131	0.214	0.889	0.279	0.334	-0.001
X4.4	0.157	0.150	0.211	0.888	0.281	0.361	0.008
X5.1	0.341	0.203	0.150	0.304	0.889	0.402	-0.015
X5.2	0.399	0.244	0.190	0.277	0.910	0.466	-0.081
X5.3	0.331	0.168	0.160	0.293	0.901	0.422	-0.049
Y1	0.351	0.428	0.330	0.396	0.430	0.916	-0.060
Y2	0.346	0.350	0.350	0.371	0.409	0.902	-0.062
Y3	0.395	0.382	0.303	0.357	0.467	0.908	-0.030
Z	-0.014	0.003	0.004	-0.003	-0.056	-0.056	1.000

1. R-Square Value

As presented in Table 6, the R² value for Implementation of UKS is 0.463, falling into the moderate category. This

indicates that 46.3% of the variance in Implementation of UKS can be explained by the exogenous variables in the model, while the remaining 53.7% is attributed to factors outside the research model.

Meanwhile, Obesity Incidence has an R^2 value of 0.024, indicating weak explanatory power, where only 2.4% of its

variance is explained by the model, and the remaining 97.6% is influenced by unmeasured external factors.

Table-6. R-square (R^2) test results.

Variable	R-square	Interpretation
Implementation of UKS	0.463	Moderate
Adolescent Obesity	0.024	Weak

2. Predictive Relevance (Q^2)

The total predictive relevance (Q^2) of the structural model is calculated using the following formula:

$$Q^2 = 1 - (1 - R^2_1) (1 - R^2_2) \dots \dots (2)$$

$$Q^2 = 1 - (1 - 0.463) (1 - 0.024)$$

$$Q^2 = 1 - (0.537) (0.976) = 0.524$$

$$Q^2 = 0.475$$

As indicated by the calculation, the structural model achieved a Q^2 value of 0.476. A Q^2 value greater than zero confirms that the structural model possesses adequate predictive relevance for the endogenous constructs.

3. F-square Value

Table-7. F-square value.

Variable	f-square
X1 -> Y	0.041
X1 -> Z	0.008
X2 -> Y	0.139
X2 -> Z	0.001
X3 -> Y	0.062
X3 -> Z	0.014
X4 -> Y	0.061
X4 -> Z	0.000
X5 -> Y	0.090
X5 -> Z	0.000
Y -> Z	0.001

4. Model Fit Test

Based on Table 8, the structural model fit was evaluated using the Standardized Root Mean Square Residual (SRMR). The estimated model achieved an SRMR value of 0.045, which is well below the threshold of 0.10 (and the conservative

The f-square (f^2) value results indicate the extent of the influence of each exogenous variable on the endogenous variable in the PLS-SEM model (Table 7). The highest effect size was observed in variable X2 with an f^2 value of 0.139, representing a small-to-medium effect on Implementation of UKS (Y). In contrast, the effect sizes of the independent variables on Adolescent Obesity (Z), as well as the effect of Implementation of UKS (Y) on (Z), yielded values approaching zero ($f^2 < 0.02$), indicating negligible effect sizes. Overall, these results demonstrate that while X2 plays a noticeable role in explaining the mediator variable, the direct contribution of the model's predictor variables to obesity incidence is relatively small.

threshold of 0.08). Furthermore, the Normed Fit Index (NFI) yielded a value of 0.866, indicating a strong alignment toward 1. These results confirm that the proposed PLS-SEM model meets the goodness-of-fit criteria and is highly suitable for further structural evaluation.

Table-8. Model fit test table.

	Rule Of Thumb	Estimated Model	Interpretation
SRMR	< 0.10	0,045	Fit
d_ ULS	> 0.05	0,519	Fit
d_ G	> 0.05	0,268	Fit
Chi-square	χ^2 statistik $\geq \chi^2$ table	483,890	Fit
NFI	Approaching 1	0,866	Fit

5. Indirect Effect

The mediating role of UKS Implementation was evaluated using a bootstrapping procedure. The results indicated that UKS Implementation did not significantly mediate the relationship between any of the ecological system levels and Adolescent Obesity. Specifically, the 95% bias-corrected confidence intervals for the indirect pathways were as follows:

As presented in Table 9, all 95% confidence intervals straddle zero, indicating that the specific indirect effects of the ecological systems on obesity incidence through UKS implementation are statistically non-significant.

6. Significance (Hypothesis Testing)

Hypothesis testing is used to analyze the direct and indirect effects of exogenous variables on endogenous variables. Hypothesis testing was used to assess the direct and indirect effects of the exogenous variables on the endogenous variables as follows:

Based on the hypothesis testing results, this study shows that all five dimensions of the Social Ecological Model have a significant direct relationship with the implementation of the UKS. However, among all the analyzed social ecological

dimensions, only the exosystem shows a direct and significant relationship with the incidence of obesity in adolescents, making the exosystem the most influential determinant in the research model. Meanwhile, the implementation of the UKS has not yet shown a significant mediating role in the relationship between social ecological determinants and the incidence of obesity in adolescents.

4- DISCUSSION

The results of this study indicate that all factors in the social-ecological model, including the school eating environment, sedentary behavior, socioeconomic status, parenting style, and eating behavior, have a significant direct relationship with the implementation of the School Health Program. However, the most crucial finding of this study is that when linked to the incidence of adolescent obesity, only the exosystem has been proven to have a significant direct influence, while the other components do not. Furthermore, the simultaneous implementation of the School Health Program has not yet been able to mediate the relationship between these social-ecological determinants and the incidence of obesity significantly. These findings suggest that the exosystem was the strongest predictor of adolescent obesity among the factors examined.

Table-9. Specific indirect effects – confidence intervals.

	Original sample (O)	Sample mean (M)	2.5%	97.5%
X1. -> Y -> Z	-0.005	-0.006	-0.034	0.020
X2. -> Y -> Z	-0.009	-0.009	-0.054	0.034
X3. -> Y -> Z	-0.006	-0.006	-0.039	0.023
X4. -> Y -> Z	-0.006	-0.007	-0.041	0.022
X5. -> Y -> Z	-0.008	-0.008	-0.047	0.031

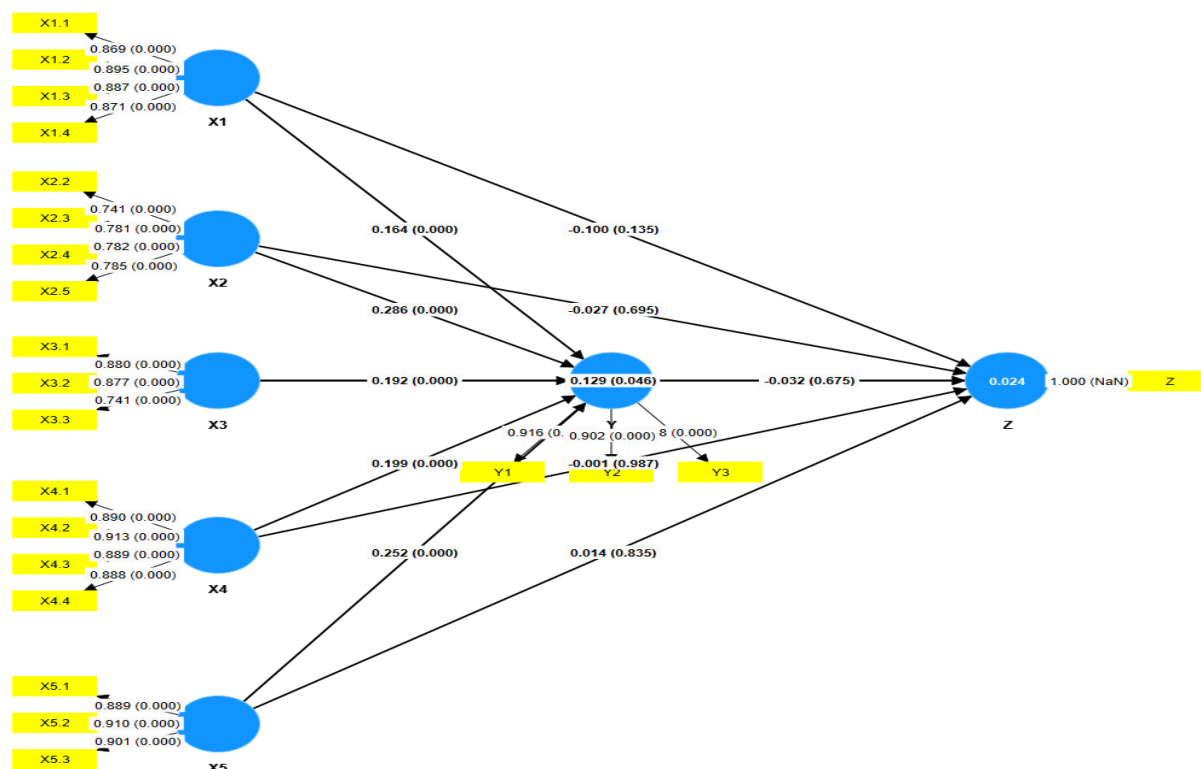


Figure-2: Results of the SEM-PLS analysis test for direct and indirect relationships.

These findings can be explained in depth through the perspective of Bronfenbrenner's Social Ecological Model (23,24). The dominance of the ecosystem over the incidence of obesity indicates that the economic capability of the family is the main component determining the family's capacity to provide resources that support health, including access to nutritious food and a conducive living environment (25). Economic limitations have the potential to create an obesogenic environment at home, where families with low economic conditions tend to choose more affordable foods that are high in energy but low in nutritional value, thereby increasing the risk of excessive calorie intake (26).

On the other hand, the inability of the School Health Program (UKS) to demonstrate significant direct or mediating roles reveals a critical evaluation of school-based health policies and their implementation in Indonesia. Regulatorily, the national framework establishes the

"Trias UKS" encompassing health education, health services, and a healthy school environment. However, empirical findings in Banyuwangi Regency highlight a substantial policy-to-practice gap between national formulation and school-level execution. The implementation of UKS remains heavily skewed toward passive cognitive health education, while active nutritional services and environmental modifications are largely neglected. Operationally, UKS facilities in target schools frequently function as mere administrative compliance or basic first-aid stations, rather than serving as active intervention mechanisms capable of addressing obesogenic canteen environments or physical inactivity among students. Although the implementation of UKS has successfully served as a vehicle for cognitive education, knowledge acquisition does not automatically translate into behavioral change or nutritional status improvement unless supported by a supportive school environment and family involvement (27). This finding aligns with

previous studies (28), which report that school-based interventions are more effective in improving health knowledge and behaviors than in reducing obesity prevalence or clinical indicators such as body mass index. Obesity is a complex multifactorial condition resulting from long-term energy imbalance; thus, alterations in body mass index require multi-component interventions, making behavioral intervention effects less visible in the short term (29).

Theoretically, this research enriches the literature by demonstrating that health outcome improvements are optimized when school nutrition interventions are integrated with surrounding environmental components (30). In practical terms, these findings highlight the need to comprehensively reorient and revitalize the UKS policy framework in Indonesia. School health policies must shift from symbolic administrative compliance to active, evidence-based intervention programs. Preventing adolescent obesity in schools requires multi-component strategies that incorporate strict nutritional standards for school canteens, structured physical activities integrated into the curriculum, a supportive school environment, and active school-family partnerships to ensure healthy lifestyle consistency between school and home settings (31,32).

Although this research provides comprehensive insights, there are several limitations. This study focuses on social-ecological determinants, while obesity is also greatly influenced by biological determinants beyond environmental control, such as genetic factors, metabolic processes, hormonal regulation, inflammatory responses, and irregular sleep duration, which also contribute to the increase in body mass index but have not yet been included as variables in this model (33,34). Based on these findings

and limitations, further research is recommended to use a longitudinal approach to evaluate the long-term impact of the UKS program on changes in body mass index. Additionally, further research is needed to test the effectiveness of multi-component intervention programs that effectively integrate health education with modifications to obesogenic environments both at school and at home.

4-1. Strengths and Limitations

Several limitations in this study need to be considered when interpreting the findings. First, data collection related to eating behavior and lifestyle relies on self-report questionnaires, which have the potential to introduce recall bias and social desirability bias. Second, obesity status is measured using a single indicator, namely the World Health Organization (WHO) BMI-for-age standard. Although practical and internationally standardized, the use of a single-item measure does not allow for the estimation of measurement error separately as in multi-indicator constructs (21), and it does not specifically depict aspects of fat distribution or body composition. Third, because this study relies on a cross-sectional design, the mediation effects tested via PLS-SEM are limited to capturing statistical associations and cannot prove a long-term causal relationship between environmental factors and changes in adolescent nutritional status.

5- CONCLUSION

This study demonstrates that while factors within the Social-Ecological Model are strongly associated with the implementation of the UKS, family socioeconomic status within the exosystem represents the sole direct determinant of adolescent obesity. Crucially, current UKS program implementation has not yet served as a significant mediator between social-ecological determinants and

adolescent nutritional status, reflecting a heavy reliance on passive cognitive health education rather than active environmental and behavioral interventions.

These findings highlight a substantial policy-to-practice gap within Indonesia's national "Trias UKS" framework. To effectively address adolescent obesity, school health policies must undergo a complete reorientation from mere symbolic administrative compliance to active, evidence-based, multi-component intervention programs. Revitalizing the UKS framework requires enforcing strict nutritional regulations for school canteens, integrating structured physical activity into daily school routines, and establishing robust school-family partnerships to maintain healthy lifestyle consistency between school and home environments.

To overcome the limitations of the cross-sectional design in this study, future research should utilize a longitudinal approach to confirm temporal cause-and-effect relationships between environmental factors and long-term changes in body mass index. Furthermore, future studies should evaluate multi-component intervention models that integrate biological determinants alongside social-ecological environmental modifications in both school and home settings.

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7- CONFLICT OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or the publication of this article.

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