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Determinants of Perceived Vulnerability to Illness among Coastal Communities in Mangrove Ecosystems

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ABSTRACT

Coastal communities living in mangrove ecosystems are exposed to various environmental and health risks that may influence their perceived vulnerability to illness. Understanding the determinants of perceived vulnerability is important for improving community health resilience. Objective: This study aimed to identify the determinants of perceived vulnerability to illness among communities living in mangrove ecosystems. An observational cross-sectional study was conducted involving 67 residents of the Baros Mangrove Ecosystem, Bantul, Yogyakarta, who were recruited consecutively. Data were collected using a structured questionnaire measuring perceived environmental health, mangrove knowledge, community participation in mangrove management, and formal education, with gender treated as a covariate. Descriptive statistics, bivariate analysis, and multiple linear regression were used to analyze the data. Perceived vulnerability to illness was significantly and negatively associated with perceived environmental health ($\beta = -1.112$, $p = 0.001$), mangrove knowledge ($\beta = -0.106$, $p = 0.032$), and formal education ($\beta = -0.106$, $p = 0.004$). Community participation showed a positive but non-significant association ($\beta = 0.181$, $p = 0.085$), while gender was not significantly associated with perceived vulnerability. The model explained 92.8% of the variance in perceived vulnerability to illness (adjusted $R^2 = 0.928$). Perceived environmental health, mangrove-related knowledge, and formal education were significantly associated with perceived vulnerability to illness among coastal communities in mangrove ecosystems. These findings highlight the potential importance of health and environmental literacy in shaping risk perceptions within coastal populations. Further studies with longitudinal designs are needed to clarify the causal relationships between these factors.

Key Messages:

- Perceived vulnerability to illness in coastal inhabitants can be minimized by enhancing health and environmental literacy.
- Understanding of mangrove ecosystem operations is important in reducing the perceived health risks.
- Environmental education and community-based interventions hold a high capacity of improving the adaptive capacity of the coastal populations.

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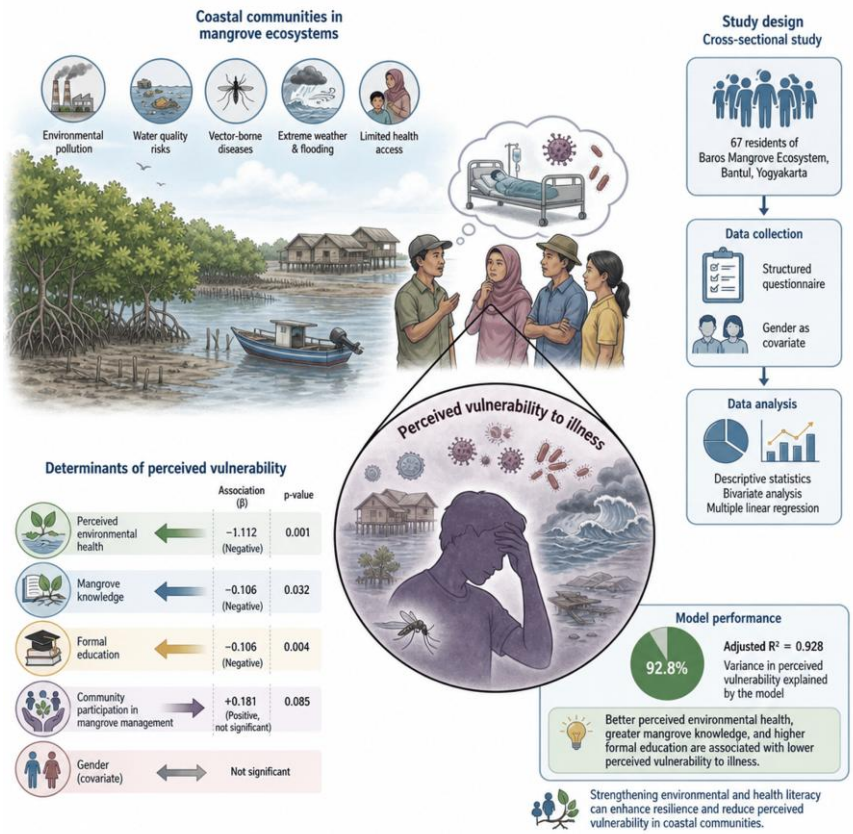
GRAPHICAL ABSTRACT



INTRODUCTION

The issue of health perceptions and disease vulnerability among communities in coastal areas has become a significant concern in the field of environmental health and eco-health (1). The environment of coastal communities is closely linked to marine and coastal ecosystems, which influence residents' livelihoods as well as their physical and psychosocial health conditions (2). Environmental factors that may lead to an increase in disease risk in coastal areas are environmental sanitation conditions, pollutant exposure, disease vectors, and exposure to natural hazards like flooding and sea-level rise (3–5). It has been shown that previous research indicates that the environment influences the presence of environmentally-related diseases in coastal communities (ex: skin and respiratory infections) in relation to environmental factors (e.g., sanitation and environmental hygiene) (6,7).

Considering the case of the coastal communities living in the mangrove wildlife zone regions, the ecological roles of a mangrove cover more than just the coast conservation through erosion prevention and flood prevention but also the community health and livelihood. Mangrove forests also offer a broad scope of ecosystem provision, such as environmental stabilization, provision of natural resources, and improvement of well-being of the adjacent populations, which in turn affect the psychological and social aspects of population health (8). The literature on cross-country research in the Asian region suggests that the communities positively impact the presence of mangroves in their well-being and the quality of life, but there is little empirical diagnostic data on health indicators (9).

However, the existing literature has largely focused on the economic value, conservation functions, and ecotourism potential of mangrove ecosystems, rather than examining the relationship between mangrove-related environmental perceptions and perceived vulnerability to illness among coastal residents. Previous studies that explored community perceptions of mangrove ecosystems have generally been descriptive, emphasizing issues such as ecosystem degradation, ecological services, and levels of community involvement in mangrove conservation (10). Although these studies provide important insights into community attitudes toward mangrove ecosystems, they rarely examine how these perceptions relate

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to individuals' perceptions of their own health risks or disease vulnerability in mangrove-dependent environments.

In addition, the interaction between social determinants—such as formal education, awareness of mangrove ecosystems, and the level of community participation in ecosystem management—and perceived vulnerability to illness has rarely been examined using quantitative approaches in mangrove-dependent coastal populations. In this study, perceived vulnerability to illness refers to an individual's subjective perception of the likelihood of experiencing health problems related to environmental conditions. This represents an important research gap because perceived vulnerability is widely recognized as a key determinant of preventive health behavior. Individuals who perceive themselves to be at lower risk may be less likely to adopt protective behaviors, thereby increasing their susceptibility to environmentally related diseases (11). Furthermore, previous studies on environmental risk perception suggest that knowledge, personal experience, and active participation in natural resource management significantly shape how communities interpret environmental health risks. However, empirical evidence examining how these socio-environmental factors interact to influence perceived illness vulnerability in mangrove ecosystems remains limited (12).

Considering these limitations, the present study aims to identify the determinants of perceived vulnerability to illness among communities living within mangrove ecosystems by examining the influence of environmental health perception, awareness of mangrove ecosystems, community participation in mangrove management, and formal education, while controlling for gender as a demographic covariate. Understanding perceived vulnerability is particularly important because it can influence how individuals respond to environmental health threats and whether they adopt preventive behaviors. By identifying the socio-environmental factors that shape these perceptions, this study provides empirical evidence that can support more targeted public health interventions in coastal communities. For example, if knowledge and awareness of mangrove ecosystems are found to be strong predictors of perceived health risk, public health programs could integrate ecosystem education with community-based health promotion strategies. Therefore, the findings of this study are expected to contribute not only to the scientific understanding of environmental health perceptions but also to the development of ecosystem-based public health policies and community participation strategies in mangrove areas.

This study aims to examine the relationships between environmental health perception, knowledge of the mangrove ecosystem, community participation in mangrove management, and perceived vulnerability to illness among coastal communities, while considering gender as a demographic variable. It is hoped that the results of the current study will be able to offer an empirical basis of developing more efficient education solutions and community participation in risk mitigation and health protection of the people in the coastal communities by means of environment-based health risks.

METHODS

Study Design and Setting

This research design used an analytical observational design that was cross sectional. The design was also chosen to investigate the relationships between social variables and environmental perceptions and perceived vulnerability to disease among communities living in coastal areas within one observation period. These relationships are important because social factors such as education, environmental knowledge, and community participation can influence how individuals interpret environmental risks and their susceptibility to environmentally related diseases. This focus addresses the limited quantitative evidence examining how social determinants such as education, environmental knowledge, and community participation shape perceived health vulnerability in mangrove coastal communities. The research was done in Baros Mangrove Ecosystem of Bantul Regency, Special Region of Yogyakarta, Indonesia. This coastal region is marked by high mangrove conservation efforts with high participation of the local community. Data collection was conducted in July 2025.

Population of the study and method of sampling

The research sample was composed of the local inhabitants of the Baros Mangrove Ecosystem who

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live and carry out daily activities in the coastal area. The sample size was 67 respondents whereby all the studied subjects were selected through consecutive sampling because this method allowed the researchers to recruit all eligible respondents who were available during the data collection period in a relatively small and geographically concentrated coastal community whereby all respondents who met all the inclusion criteria and exclusion criteria were recruited in that order until the required number of respondents was reached. The inclusion criteria were: the person has to live within the coastal region where the Baros mangrove ecosystem is located, is above 18 years old, and should agree to take part in the study. The exclusion criteria were the respondents who failed to answer the questionnaire fully and those who were not able to communicate well in the process of data collection.

Study Variables

Perceived vulnerability to illness was the dependent variable in this study. The independent variables were environmental health perception, mangrove environment knowledge, community participation in managing the mangrove ecosystem, and formal education. These variables were selected because previous environmental health studies suggest that knowledge, environmental awareness, and community engagement influence risk perception and preventive health behavior in environmentally vulnerable communities**.** Gender was added as covariate in the analysis.

Data Collection Techniques and Instruments

A structured questionnaire was used to gather data, developed through a thorough literature review and adapted to the local context of mangrove coastal communities. The variables included in the instrument—environmental health perception, mangrove knowledge, and community participation—were selected to generate evidence that may guide community-based environmental health education and ecosystem management interventions in coastal areas. The respondents filled the questionnaire themselves though with the help of the researchers in order to make the respondents understand the questions and provide answers to all questions.

Perceived environmental health was assessed based on 13 items on a five-point Likert scale, which included some of the indicators that represented the evaluation of respondents of the quality of the physical environment and environmental health threats and mangrove ecosystems and their role in health, and environmental control and concern. The perception of environmental health score was determined by adding all the item scores.

The knowledge of mangrove environment was measured based on 8 items using a three-point Likert scale which included the respondents knowledge regarding the mangrove ecological functions, the effects of degradation and waste, the differences in the species of mangroves, the connection between environmental conditions and the type of mangroves, the suitability of mangroves in conservation and the economic benefits of mangroves. The score on knowledge was obtained by adding up all the items.

The community participation in the management of mangrove ecosystem was quantified based on 20 questions on a three-item Likert scale that defines the level of involvement of the respondents in different phases of managing the mangrove. These phases involved socialization and meetings, exchange of ideas, planning and education, social mobilization, facilities and policy support, education, conservation activities (establishing nursery, planting, replanting and cleaning of wastes), monitoring and reporting and perceptions of the mangrove benefits in terms of protecting the coastal and livelihoods. The score of participation was the sum of the items.

Perceived vulnerability to illness was assessed using 12 items on a five-point Likert scale, which included the perception of the risk of sickness, the exposure of the environment, vulnerability of family members, and diseases caused by the environment, and vulnerability to long-term health. The scores that survived are higher, which means that the perceived level of vulnerability to illness is higher. The formal education was found on the highest level of formal education of the respondents and the levels were categorized based on the level of formal education.

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Data Analysis

The analysis of data was conducted step by step. The characteristics of the respondents and the distribution of all variables were summarized through descriptive analysis. Identifying the determinants of perceived vulnerability is important because perception of health risk is widely recognized as a key predictor of preventive health behavior in environmentally exposed communities. Then, multivariate analysis was conducted using multiple linear regression to determine the determinants of perceived vulnerability to illness, including all independent variables along with gender as a covariate. This analytical approach allows the study to quantitatively assess the relative contribution of social and environmental determinants to perceived health vulnerability among coastal mangrove communities. This analytical approach allows the study to quantitatively assess the relative contribution of social and environmental determinants to perceived health vulnerability among coastal mangrove communities. The effects of the independent variables were evaluated jointly using the F-test and individually using the t-test. Statistical significance was set at $p < 0.05$.

Research Ethics

Each respondent was given an elaborate explanation of the study objectives, procedures, benefits, and possible risks before engaging into data collection. Each participant gave an informed consent in written form, and the confidentiality of personal data was guaranteed throughout the study and after it.

RESULTS

Descriptive Analysis of Respondents and Study Variables

Descriptive analysis was used to define the features of respondents and distribution of each variable of the study. Means and standard deviations are used to represent numerical variables, frequencies and percentages represent categorical variables as indicated in Table 1. Table 1 presents the demographic characteristics of respondents (gender and formal education) as well as descriptive statistics of the main study variables, including perceived environmental health, knowledge of mangroves, community participation, and perceived vulnerability to illness. These statistics provide an overview of the distribution and variability of each variable among the coastal community respondents.

Table 1. Characteristics of Study Respondents (n = 67)

Variable / Characteristic	Category	n	%	Min Score	Max Score	Mean	SD
Gender	Male	34	50.7	–	–	–	–
	Female	33	49.3	–	–	–	–
Formal Education	Primary school	3	4.5	–	–	–	–
	Junior high school	12	17.9				
	Senior high school/ vocational school	41	61.2	–	–	–	–
	Higher education	11	16.4	–	–	–	–
Perceived environmental health	–	–	–	35	63	49.2	8.4
Knowledge of Mangroves	–	–	–	14	24	20.2	3.4
Community Participation	–	–	–	38	59	49.0	5.4
Perceived Vulnerability to Illness	–	–	–	30	52	39.1	6.6

Multiple Linear Regression Classical Assumption Tests

Before the multiple linear regression analysis, classical assumption tests were done to make sure that the model was within the statistical requirements.

Normality Test

The Shapiro–Wilk test was used to assess the normality of the regression residuals because it is recommended for small sample sizes ($n < 200$). The results of the residual normality test are presented in Table 2.

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Table 2. Residual Normality Test (Shapiro–Wilk)

Variable	Shapiro–Wilk Statistic	df	p	Interpretation
Unstandardized residuals	0.982	67	0.356	Normally distributed

Linearity Test

Linearity between the continuous independent variables and perceived vulnerability to illness was assessed using the ANOVA test of linearity. As presented in Table 3, perceived environmental health ($F = 24.87$, $p < 0.001$), knowledge of mangrove ecosystems ($F = 7.45$, $p = 0.008$), participation in mangrove management ($F = 19.63$, $p < 0.001$), and formal education ($F = 4.21$, $p = 0.044$) showed statistically significant linear relationships with perceived vulnerability to illness. Furthermore, the deviation from linearity for all variables was not statistically significant ($p > 0.05$), indicating no evidence of non-linear relationships. These findings suggest that the linearity assumption required for multiple linear regression analysis was satisfied.

Table 3. Test of Linearity between Independent Variables and Perceived Vulnerability to Illness

Independent Variable	F (Linearity)	p	F (Deviation from Linearity)	p	Conclusion
Perceived Environmental Health	24.87	< 0.001	1.12	0.351	Linear
Knowledge of Mangrove Ecosystems	7.45	0.008	0.94	0.512	Linear
Participation in Mangrove Management	19.63	< 0.001	1.08	0.389	Linear
Formal Education	4.21	0.044	0.76	0.472	Linear

Multicollinearity Test

Tolerance values and Variance Inflation Factor (VIF) were used to assess multicollinearity among independent variables. Variables with tolerance values close to 0.10 and VIF values approaching 10 indicate potential multicollinearity problems. Table 4 shows the outcome of the multicollinearity test.

Table 4. Multicollinearity Test of Independent Variables

Independent Variable	Tolerance	VIF	Remarks
Perceived environmental health	0.119	8.429	Indicates potential multicollinearity risk
Knowledge of Mangrove Ecosystems	0.469	2.133	No indication of multicollinearity
Participation in Mangrove Management	0.102	9.784	Indicates potential multicollinearity risk
Formal Education	0.862	1.160	No indication of multicollinearity
Gender	0.833	1.201	No indication of multicollinearity

Heteroscedasticity Test

The heteroscedasticity was tested using a scatterplot of the residual values versus the predicted values. Figure 1 displays the results of heteroscedasticity test.

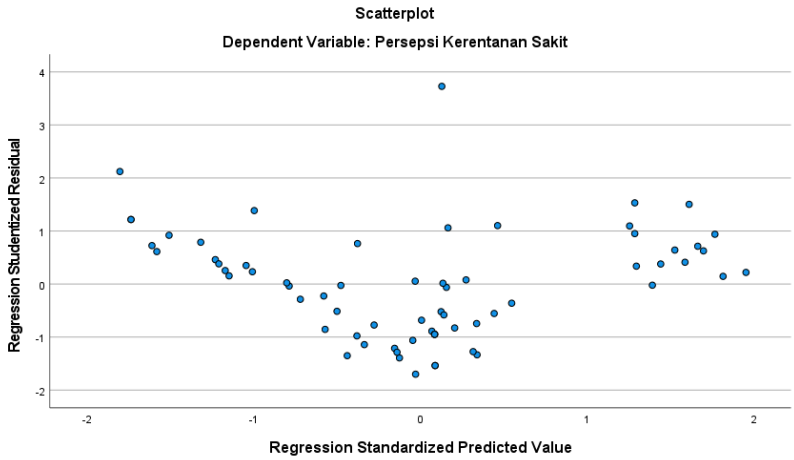

Figure 1. Scatterplot of residuals versus predicted values

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Results of the Simultaneous Test of Multiple Linear Regression

To assess the simultaneous effect of the independent variables in explaining variations in perceived vulnerability to illness among coastal communities in mangrove ecosystems, a simultaneous test (F-test) was conducted on the constructed multiple linear regression model. The results of the F-test are presented in Table 5.

Table 5. Results of the F-Test of the Multiple Linear Regression Model for Determinants of Perceived Vulnerability to Illness among Coastal Communities in Mangrove Ecosystems

Model	Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2719.321	5	543.864	171.942	< 0.001
	Residual	192.948	61	3.163		
	Total	2912.269	66			

Note: Perceived Vulnerability to Illness is the dependent variable. Predictors: Perceived Environmental Health, Knowledge of Mangrove Ecosystems, Community Participation, Formal Education, and Gender

Multiple Linear Regression Analysis

Multiple linear regression analysis was conducted to identify the determinants of perceived vulnerability to illness among coastal communities in mangrove ecosystems by simultaneously entering all independent variables and covariates into the model. Regression coefficient estimates, significance levels, and confidence intervals are presented in Table 6.

Table 6. Results of the Multiple Linear Regression Analysis on Perceived Vulnerability to Illness

Predictor	B	SE	β	t	p	95% CI for B
Constant	78.339	2.537	—	30.873	< .001	[73.265, 83.413]
Perception of Environmental Health	−0.882	0.076	−1.112	−11.624	< .001	[−1.034, −0.731]
Knowledge of Mangrove Environment	−0.205	0.093	−0.106	−2.197	0.032	[−0.392, −0.018]
Community Participation	0.224	0.128	0.181	1.752	0.085	[−0.032, 0.479]
Formal Education	−0.975	0.327	−0.106	−2.981	0.004	[−1.630, −0.321]
Gender	0.134	0.476	0.010	0.281	0.779	[−0.818, 1.086]

Note: The dependent variable is Perceived Vulnerability to Illness.

Based on Table 5, perceived environmental health (β = −1.112, p <0.001), knowledge of mangrove ecosystems (β = −0.106, p = 0.032), and formal education (β = −0.106, p = 0.004) were significantly associated with perceived vulnerability to illness. In contrast, community participation (β = 0.181, p = 0.085) and gender (β = 0.010, p = 0.779) were not statistically significant predictors. The standardized beta coefficient for perceived environmental health exceeded |1| (β = −1.112), which may occur under conditions of high multicollinearity among predictors. Therefore, the interpretation of this coefficient should be treated with caution.

Model Summary

A model summary analysis was done to determine the strength and predictive ability of the regression model that included the correlation coefficient (R), coefficient of determination (R^2), the adjusted R^2, and the standard error of the estimate. Table 7 shows the summary of the multiple linear regression model. The model produced a high coefficient of determination ($R^2 = 0.934$), indicating that the predictors explained a large proportion of variance in perceived vulnerability to illness. However, this unusually high value may be influenced by the relatively small sample size and the presence of multicollinearity among some predictors. Therefore, the findings should be interpreted cautiously.

Table 7. Summary of Multiple Linear Regression Model Perceived Vulnerability to Illness

Model	R	R^2	Adjusted R^2	SE of the Estimate
1	0.966	0.934	0.928	1.779

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DISCUSSION

The findings of this research show that there is a strong relationship between the environmental health perception, awareness of the mangrove environment and formal education and perceived vulnerability to illness among the coastal communities residing in the Baros mangrove ecosystem, Bantul Regency. Conversely, there was a positive but non-significant relationship between community participation and there was no significant effect of gender, which is a covariate. This finding suggests that while community engagement in environmental activities may strengthen social attachment to the mangrove ecosystem, it does not necessarily translate into individual perceptions of health vulnerability. Participation activities often emphasize environmental conservation rather than explicit health-risk communication, which may explain the absence of a statistically significant relationship with perceived vulnerability to illness. These results give significant information on determinants of health risk perception in the people living in the coastal areas who live in symbiosis with mangrove ecosystems. In addition, it is important to acknowledge that all constructs in this study were measured using structured questionnaires developed based on theoretical frameworks of environmental health perception and mangrove ecosystem knowledge. Prior to the main survey, the instruments underwent validity and reliability testing, indicating acceptable psychometric properties. Nevertheless, because the constructs were assessed through self-reported perceptions, measurement error and response bias cannot be fully excluded. Future studies should incorporate validated scales and objective environmental indicators to strengthen construct validity.

Perceived environmental health as the Key Predictor

The regression coefficients indicate that perceived environmental health is negatively related to perceived vulnerability to illness to a significant level ($\beta = -0.882$, $p < 0.001$). However, the standardized coefficient exceeded an absolute value of 1 ($\beta = -1.112$), which may occur under conditions of multicollinearity among predictors. The variance inflation factor (VIF) values observed in the model indicate potential multicollinearity between perceived environmental health and community participation. Therefore, the magnitude of this coefficient should be interpreted with caution, as it may partly reflect statistical inflation rather than a purely substantive relationship. This shows that those who have positive perceptions of their environmental health conditions are likely to perceive themselves as less vulnerable to disease. This observation is in line with the past research showing that the perception of health risks is highly dependent on the way communities evaluate the quality and the risks of the immediate environment (risk perception) (13). Better perceptions of environmental conditions will reduce the existence of misconceptions and disproportional health-related anxiety that do not correspond with the actual risk (perceived risk), thus resulting in more rational perceived vulnerability to illness (14).

Cognitive and affective factors also influence environmental risk perception as it is demonstrated in the research on risk perception in the context of exposure to environmental compounds, where communities tend to assess risks in terms of experience and knowledge about possible risk (15). This perspective supports the argument that environmental knowledge and perceived environmental quality may play a more direct role in shaping perceived vulnerability than social participation variables.

The Role of Knowledge on the Mangrove Environment

Mangrove environmental knowledge was also found to have a negative and significant relationship with perceived susceptibility to illness ($\beta = -0.205$, $p = 0.032$). It means that the more the respondents know about functions and roles of mangrove ecosystems, the less vulnerable they are about being ill. One plausible mechanism is that knowledge enhances an individual's sense of environmental control and understanding of ecosystem services. Communities that understand the ecological functions of mangroves—such as shoreline protection, water filtration, and habitat support—may perceive environmental risks more realistically rather than overestimating their vulnerability to illness. In the context of the Health Belief Model, knowledge may therefore influence perceived susceptibility through cognitive appraisal and environmental awareness. It means that the more the respondents know about functions and roles of mangrove ecosystems, the less vulnerable they are about being ill. This result adds

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to the support of the Health Belief Model and existing literature that indicated knowledge had a part to play in the creation of a more realistic risk perception (16). Appropriate understanding of mangroves would facilitate better awareness of communities on the ecosystem services that can be offered by mangroves, such as protection of the shoreline, filtration of pollutants, as well as the overall support of the health of the community which may not be conspicuous (17). The same study has found that the perceptions of community regarding the benefits of mangrove and its functions are positively correlated with the level of knowledge about mangroves, which is also evident in other studies on the perceptions of the community towards mangroves in Indonesia (18).

Community Participation in Mangrove Management

There was a positive coefficient ($\beta = 0.224$) that was not statistically significant ($p = 0.085$). This implies that even though their engagement in mangrove-related activities, including meetings, training programs, or conservation efforts, can enhance attachment of respondents to their environment the involvement is not powerful enough to outstandingly affect perceptions of vulnerability to illness (19). This can be explained by the fact that participation is also predominantly social or structural, and perceptions of health vulnerability are affected more directly by the immediate physical exposure and personal health outcomes (20). Therefore, participation may function indirectly by strengthening environmental awareness and collective learning rather than directly shaping individual cognitive risk perception. A number of studies have also revealed that community participation in natural resources management is usually influenced by the complex local and sociocultural circumstances, which leads to the relationships with health perceptions that are not always linear and statistically significant (21,22).

Effect of Formal Education

The findings demonstrate that the formal education is significantly and negatively related to the sensed vulnerability to the illness ($\beta = -0.975$, $p = 0.004$), meaning that those educated respondents are more likely to report the low perceived vulnerability to the disease. Formal education may influence perceived vulnerability through improved analytical and critical-thinking skills that enable individuals to interpret environmental health information more accurately. In coastal–mangrove contexts, educated individuals may better distinguish between perceived environmental threats and the protective ecological functions provided by mangrove ecosystems, thereby forming a more balanced perception of health risks.

This observation aligns with the existing knowledge on formal education in the field of public health that suggests that formal education increases the ability of individuals to understand health risk information and make more correct judgments about environmental determinants of health (23,24). The greater the formal education, the more critical thinking can help to assess health-related cases, the lesser the vulnerability to misperception, and the greater the acceptance of more productive adaptive response (25).

No Significant Effect of Gender

Gender, included as a covariate, was not significantly associated with perceived vulnerability to illness ($p = 0.779$), indicating that within the context of the Baros mangrove ecosystem coastal community, gender differences do not constitute a primary determinant of health risk perception. One possible explanation is that both men and women in this community share relatively similar environmental exposures and knowledge regarding mangrove ecosystem functions, which may reduce gender-based differences in environmental health risk perception. This finding aligns with previous studies reporting that gender is not a significant factor in health risk perception, suggesting that cultural context mediates risk perception to a greater extent than gender itself (26). This result is noteworthy, as some prior studies conducted in other communities have reported gender-based differences in risk perception; however, such effects are often contingent upon the specific socio-cultural characteristics of the study setting (27).

Model Strength and Implications

The multiple linear regression model accounts for 93.4% of the variation in perceived vulnerability

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to illness (Adjusted R^2 = 0.928). Although this value suggests a strong explanatory capacity, such a high coefficient of determination is uncommon in social and public health research. This value may be influenced by several methodological factors, including the relatively small sample size, potential multicollinearity among predictors, and the possibility of common method bias because all variables were measured using self-reported questionnaires collected at the same time. Therefore, the model should be interpreted cautiously and not as definitive evidence of extremely strong determinants. The findings indicate the relevance of multidimensional approach to the conceptualization of environmental health risk perception among coastal communities-including personal perception of the environmental conditions, ecological knowledge, and the formal educational. These findings highlight that cognitive and informational factors may play a more substantial role in shaping perceived vulnerability to illness than purely demographic or participatory variables.

These outcomes make policy and environmental health program level stress that education interventions and the target to increase the level of community knowledge on issues of significance on the environment and health must be prioritized. Strengthening environmental literacy and ecosystem-based health education programs may help communities develop more accurate perceptions of environmental health risks while simultaneously supporting sustainable mangrove ecosystem management. Awareness campaigns and environmental literacy programs may play an important role in improving environmental health perceptions. However, because community participation was not statistically significant in predicting perceived vulnerability in this study, participation-based interventions should not be interpreted as direct determinants of health risk perception. Instead, participation may function indirectly by strengthening environmental knowledge, collective awareness, and local ecological stewardship.

Study Limitations

First, the cross-sectional study design does not allow one to make causal conclusions about variables. Second, the relatively small sample size (n = 67) represents an important limitation and may increase the risk of model overfitting, particularly given the number of predictors included in the regression model. This limitation may partly explain the unusually high R^2 value observed in the analysis. Third, the study was conducted in a single coastal site (Baros mangrove ecosystem), where community participation in mangrove conservation is already relatively high; therefore, the findings may not be fully generalizable to other coastal communities with different socio-ecological conditions. Fourth, the cross-sectional design prevents causal inference and may also introduce common method bias because all variables were measured using self-administered questionnaires at the same time. Fifth, the study relied on perception-based indicators without objective environmental or health measurements (e.g., disease incidence or environmental quality indicators), which may limit the triangulation of findings.

CONCLUSION

This study examined determinants of perceived vulnerability to illness among coastal communities in the Baros mangrove ecosystem and found that environmental health perception, mangrove ecosystem knowledge, and formal education were significant predictors, with environmental health perception showing the strongest statistical association in the regression model rather than implying causal dominance. Community participation and gender were not significant predictors in the model.

These findings suggest that cognitive and perceptual factors related to environmental conditions and ecosystem knowledge may contribute to shaping perceived health risks in mangrove-dependent coastal communities. However, the findings should be interpreted cautiously because the study involved a relatively small sample (n = 67) from a single site and the regression model showed potential multicollinearity and an unusually high R^2 value (0.934).

Environmental health initiatives in coastal areas may benefit from strengthening ecological literacy related to mangrove ecosystem functions and their links to human health, particularly through education-based programs that improve community understanding of environmental risks and ecosystem protection mechanisms. Nevertheless, these recommendations should be viewed as preliminary implications derived from a cross-sectional analysis. Future studies with larger and more diverse samples

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are needed to validate these findings and to further explore how ecological knowledge, participation, and environmental perception interact in shaping health risk perception in coastal ecosystems.

DECLARATION OF THE USE OF AI

The authors declare that no artificial intelligence (AI), AI-assisted technologies, or large language models (LLMs) were used in the conception of the study, data analysis, or the drafting, writing, and editing of this manuscript. The only exception is the graphical abstract, which was created using the design platform Illustrae (https://illustrae.co/). The authors take full responsibility for the content and accuracy of the graphical abstract and the entire manuscript.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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