Krish Naufal Anugrah Robby

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An Epidemiological Management Approach to Stroke Disease in Coastal Communities: A Structural Model for Tertiary Prevention

Krish Naufal Anugrah Robby[1]*, Isa Ma'rufi[2], El houssin Ouassou[3]

[1,2]Faculty of Public Health, Universitas Jember, Jember, East Java, Indonesia
[3]Faculty of Law, Economics & Social sciences of Agdal, Mohammed V University in Rabat, Rabat, Morocco.

ABSTRACT

Background: Stroke survivors in coastal areas face major challenges, such as limited access to health services, minimal post-stroke education, and inadequate routine monitoring. Without a targeted tertiary prevention strategy, the risk of recurrence and disability remains high. This study aims to develop a stroke management model to enhance self-control and support community-based health policy planning**.**
Methods: A cross-sectional study was conducted among 45 stroke survivors in Puger Subdistrict, Jember Regency, using a total sampling approach. Data were collected through questionnaires and measurements of blood pressure, cholesterol, and random blood glucose using Touch Based Device and digital sphygmomanometers. Path analysis was performed using Partial Least Squares–Structural Equation Modeling.
Results: Clinical needs, such as elevated blood pressure and cholesterol levels, encouraged survivors to be more active in managing their condition and increased interactions with health services. However, paradoxically, poor self-management—such as infrequent blood pressure monitoring and unhealthy diets—placed a greater burden on the health system. This indicates that an increased system response alone is insufficient without strengthening individual roles. Family history and blood glucose levels also contributed through indirect pathways.
Conclusion: Preventing stroke recurrence requires a comprehensive epidemiological management approach, including clinical control, dietary education, and sustainable community-based interventions. This model can serve as a basis for designing health programs and policies that are more responsive to the needs of coastal communities**.**
Keywords: stroke; tertiary prevention; managerial epidemiology; coastal areas; health policy

**Corresponding author, krishnaufal@unej.ac.id*

Introduction

Stroke is the leading cause of death and long-term disability worldwide. Each year, more than 12 million new cases occur globally, with an estimated 7.3 million deaths and millions of survivors living with complex neurological dysfunction [1]. In Indonesia, based on the 2018 Riskesdas, the prevalence of stroke reached 10.9 per 1,000 population. Coastal areas, such as Southeast Maluku, even recorded a higher prevalence, at 12.6‰, with ischemic stroke as the dominant form of 95.3%.[2]

Although acute stroke therapy has made significant progress, the implementation of tertiary prevention in communities with limited resources—such as coastal areas—still faces many obstacles. Primary service systems in these areas often do not provide ongoing support such as adequate blood pressure monitoring, metabolic regulation, and long-term rehabilitation. Research by Nakibuuka et al. (2021) in Uganda shows that lack of community support, limited medicines, and low levels of family health literacy are the main barriers to successful stroke recurrence prevention, especially in remote and resource-poor areas. Similar barriers can also be encountered in Indonesia's coastal communities that have limited geographical conditions and access to health services [3].

Tertiary prevention is essential to lower the risk of recurrence, accelerate functional recovery, and improve the quality of life of stroke survivors. Unfortunately, survivors in rural and coastal areas often do not receive adequate education about blood pressure, cholesterol, and blood sugar control. Many families are unable or unaware of how to continue therapy after the patient is discharged from a health facility. International studies have shown that these barriers include limited knowledge, insufficient resources, and a lack of rehabilitation professionals [4,5].

In addition, the health system's response to stroke in this area is still reactive rather than preventive. Healthcare services are more often reached when patients are already in a state of crisis, rather than as part of long-term risk control. Even hospitals that are classified as ready face challenges in implementing thrombolytic therapy and comprehensive rehabilitation programs in a timely manner in rural areas [6].

In response to this situation, the development of a model of stroke epidemiology management based on tertiary prevention is very important. This model needs to include integration between clinical data, metabolic status, socio-economic conditions, as well as primary health system responses to produce more adaptive and sustainable intervention strategies in coastal communities. This study aims to build a causality model that explains the main factors that affect the quality of stroke management, with the hope of improving the effectiveness of the health care system and improving the quality of life of stroke survivors in resource-constrained areas.

Method

This study uses a quantitative approach with *a cross-sectional* design to analyze the influence pathways between socio-demographic factors, metabolic clinical status, consumption behavior, and health system response to stroke management in coastal areas. The research location is in the working area of the Puger District Health Center, Jember Regency, which represents coastal communities with limited resources in handling non-communicable diseases.

The subjects of the study were stroke survivors, i.e. individuals who had received a stroke diagnosis from a hospital and now live in the community. A total of 45 individuals were identified, all of whom met the inclusion criteria and agreed to participate, Therefore, total sampling was employed.

Inclusion criteria: (1) diagnosis of stroke by medical personnel in formal health facilities, (2) permanent domicile in the coastal area of Puger District, and (3) able to participate in interviews and examinations. Respondents are excluded if they have a severe disability or do not complete the data collection process. Data collection was conducted out through home visits, assisted by local health cadres.

The research instruments consisted of structured questionnaires and clinical examinations covering sociodemographic characteristics, socioeconomic status, family history of stroke and hypertension, and food consumption. And blood pressure, total cholesterol levels, and *random blood sugar (GDA).* GDA and cholesterol measurements were carried out using touch based devices This studies has been proven to have high accuracy and precision in glucose monitoring in the field. Blood pressure is measured using a calibrated digital sphygmomanometer. The GDA cut-off ≥ 200 mg/dL follows WHO/AHA guidelines. The study variables were grouped into several latent constructs, namely: anthropometric status (weight and abdominal circumference); socioeconomic status and formal education; family history of stroke and hypertension; comprehensive clinical needs (combined cholesterol levels and blood pressure); random blood sugar status; system response to risk (access to health services and control of GDA levels); and stroke disease management.

Stroke disease management in this study is defined as a series of structured efforts made by stroke survivors to independently control secondary and tertiary risk factors, with the aim of preventing recurrence, accelerating recovery, and maintaining optimal quality of life. This concept includes managing blood pressure and cholesterol levels, improving food consumption patterns (especially fruit, vegetable consumption, and reducing saturated fat), and making informed decisions in accessing health services when warning symptoms occur. This definition aligns with guidance from the American Stroke Association, which emphasizes the importance of *post-stroke self-management* as part of community-based tertiary prevention, as well as a rehabilitative approach that emphasizes lifestyle changes, medication adherence, and ongoing monitoring.[7] Each management indicator is encoded in a dichotomous form (good = 0, bad = 1).

Data analysis is carried out in stages. Univariate analysis was conducted using SPSS version 26 to describe the distribution of respondent characteristics. Furthermore, a multivariate analysis was carried out with the Partial Least Squares – Structural Equation Modeling (PLS-SEM) approach through SmartPLS software version 4. The model evaluation included a convergent validity test (Average Variance Extracted / AVE), composite reliability (CR), and a path coefficient test using *a bootstrapping* technique with 5,000 subsamples, referring to the approach [8] .All research procedures have received ethical approval from the Health Research Ethics Commission of Dian Nuswantoro University, with certificate number: 001458/DIAN NUSWANTORO UNIVERSITY/2025.

Result

Descriptive Analysis of Respondent Characteristics

The characteristics of respondents with stroke in coastal areas include sociodemographic aspects, clinical conditions, consumption behavior, and access to health services. Table 1 presents the distribution of respondents based on variables of age, gender, socioeconomic status, education, body mass index, stroke history, history of hypertension, and control status of risk factors such as blood pressure, cholesterol levels, and blood sugar. In addition, this table also illustrates individual responses to stroke risk and patterns of access to healthcare facilities in coastal areas.

Table 1. Characteristics of Respondents with Stroke on the Coast

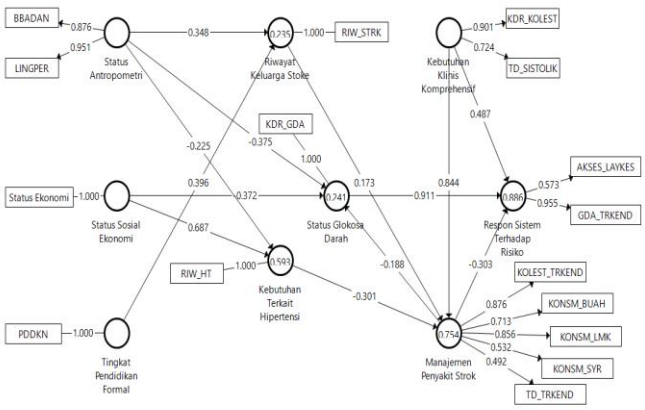
Variable	**Respondents (n)**	**Percentage (%)**
Age		
35-45 years old	6	13.3
46-55 years old	18	40.0
>55 years old	21	46.7
Gender		
Woman	15	33.3
Man	30	66.7
Economy class		
Lower class (below UMR)	12	26.7
Middle Class	33	73.3
Work		
Not working	30	66.7
Productive Work (Fishermen and Self-Employed)	15	33.3
Education		
Primary education (Not school, elementary, junior high)	36	80
Secondary Education (SMA)	9	20.0
Body Mass Index		
Lack of heavy BB	15	33.3
Disadvantages of a mild level BB	9	20.0
Usual	21	46.7
Family Stroke History		
Yes	9	20.0
Not	36	80.0

Variable	Respondents (n)	Percentage (%)
Family History of Hypertension		
Yes	27	60.0
Not	18	40.0
System response to risk		
Access to healthcare		
Not accessing Yankes or Non-Traditional Medical (Masseuse/Never)	6	13.3
Partial Pharmaceutical/Partial Individual (Pharmacy, Independent Practice)	9	20.0
Tertiary Medical Formal, Primary Medical Formal, Non-Government Formal (Hospitals, Health Centers, Clinics)	30	66.7
Controlled Blood Sugar Status		
Yes (<140)	39	86.7
No (≥200)	6	13.3
Stroke Disease Management		
Cholesterol Status Under Control		
No (≥200 mg/dL)	30	66.7
Yes (<200 mg/dL)	15	33.3
Fruit Consumption Status		
Often	21	21.0
Infrequently	24	24.0
Fat Consumption Status		
Often	30	33.3
Infrequently	15	66.7
Vegetable Consumption Status		
Often	6	13.3
Infrequently	39	86.7
Controlled Blood Pressure Status		
Out of Control	33	73.3
Respondents Controlled	12	26.7
Comprehensive clinical needs	**Mean**	
Cholesterol Levels	210.33	
Systolic Blood Pressure	170	
Diastolic Blood Pressure	121.46	
Blood Glucose Status		
Blood Sugar Levels	147.66	

All participants in this study were stroke patients residing in coastal areas. The majority are men (66.7%) with the largest age group over 55 years old (46.7%). Most have a low level of education (80.0%) and belong to the middle socioeconomic working class (73.3%) with unemployed status (73.3%). In terms of nutritional status, one-third of respondents were underweight, while the other third was in the normal nutrition category. A history of recurrent stroke was found in 44.4% of respondents, while 80.0% had no previous history of hypertension.

In the context of health risk management in coastal communities, most of the respondents with stroke had their blood pressure under control (86.7%). However, total cholesterol levels showed an average of 210.33 mg/dL, which was relatively high, and fasting blood sugar levels showed an average of 147.66 mg/dL, which was above normal limits. Food consumption patterns showed that 33.3% of respondents frequently consumed high-cholesterol foods and 24.0% often consumed high-fat foods. Efforts to prevent the risk of stroke were carried out by 60.0% of respondents, while access to health services dominated by the use of formal facilities such as health centers and clinics (66.7%), reflecting the still limited access to health services in coastal communities

Evaluation of Measurement Model



Picture 1. Path diagram illustrating the measurement model of stroke disease management in coastal areas

Table 2. *Measurement Model*

Latent Construct	Indicators	*Outer Loading*	Information
Anthropometric status	BBADAN (Weight)	0.876	Valid
	LINGPER (Abdominal Circumference)	0.951	Valid
Socioeconomic status	Economic status	1.000	Valid
Level of formal education	PDDKN (Education)	1.000	Valid
Family history of stroke	RIW_STRK (Family history of stroke)	1.000	Valid
Blood Glucose Status Blood Pressure	KDR_GDA (Blood Sugar Level)	1.000	Valid
Hypertension-Related Needs	RIW_HT (Family History of Hypertension)	1.000	Valid
Comprehensive Clinical Needs	KDR_KOLEST (Cholesterol Levels)	0.901	Valid
	TD_SISTOLIK (Systolic Blood Pressure)	0.724	Valid
System Response to Risk	AKSES_LAYKES (Access to Health Services)	0.573	Valid

Latent Construct	Indicators	*Outer Loading*	Information
	GDA_TRKEN (Controlled Blood Sugar Status)	0.955	Valid
Stroke Disease Management	KOLEST_TRKEND (Controlled Cholesterol Status Levels)	0.876	Valid
	KONSM_BUAH (Fruit Consumption Status)	0.713	Valid
	KONSM_LMK (Fat Consumption Status)	0.856	Valid
	KONSM_SYR (Vegetable Consumption Status)	0.532	Valid
	TD_TRKEND (Controlled Blood Pressure Status)	0.492	Valid

As presented in Picture 2 and Table 2, all latent constructs in the measurement model were measured using indicators that demonstrated satisfactory outer loading values, with all exceeding the minimum threshold of 0.40 (Hair et al., 2019). Constructs such as Socioeconomic Status, Formal Education Level, Family History of Stroke, and Blood Glucose Status showed perfect loading values (1.000), indicating very strong indicator reliability. Other constructs including Anthropometric Status (0.876–0.951), Hypertension-Related Needs (0.901–1.000), Comprehensive Clinical Needs (0.724–0.901), System Response to Risk (0.573–0.955), and Stroke Disease Management (0.492–0.876) also exhibited acceptable levels of indicator validity.

Further elaboration is illustrated in Figure 1, which shows the structural model of Stroke Disease Management in Coastal Communities. The figure highlights both direct and indirect relationships between constructs. Notably, Status of Blood Glycosis emerged as a central construct, having a strong direct effect on Stroke Disease Management (β = 0.844) and System Response to Risk (β = 0.911). Additionally, Hypertension-Related Needs (β = 0.318), Comprehensive Clinical Needs (β = 0.487), and Anthropometric Status (β = –0.225) contributed significantly, either directly or indirectly, to the variance explained in stroke management outcomes. These findings affirm the internal consistency and structural validity of the model in evaluating key health factors influencing stroke control in coastal populations.

Table 3. Evaluation of Reliability and Construct Validity in the PLS-SEM Measurement Model

	Composite Reliability
Comprehensive Clinical Needs	0.799
Hypertension-Related Needs	1.000
Stroke Disease Management	0.830
System Response to Risk	0.754
Stoke Family History	1.000
Anthropometry Status	0.910
Status of Blood Glycosis	1.000
Socioeconomic Status	1.000
Formal Education Level	1.000

As shown in Table 3, the results of the construct reliability evaluation indicate that all latent variables in the measurement model achieved Composite Reliability (CR) values above the threshold of 0.70, demonstrating acceptable internal consistency (Hair et al., 2019). The highest CR values (1.000) were recorded in the constructs of *Socioeconomic Status, Formal Education Level, Stroke Family History, Hypertension-Related Needs,* and *Status of Blood Glycosis*. These were followed by *Anthropometry Status* (0.910), *Stroke Disease Management* (0.830), *Comprehensive Clinical Needs* (0.799), and *System Response to Risk* (0.754). These findings confirm that all constructs in the model have good reliability and are suitable for further structural model analysis.

Structural Model Evaluation

Social Inequality and Nutrition Fueling Blood Sugar Spikes: A Portrait of Double Risk Stroke Sufferers on the Coastal

Table 4. Social Inequality and Nutrition Trigger Blood Sugar Spikes

	Original Sample (O)	*Standard Deviation (STDEV)*	*T Statistics (|O/STDEV|)*	*P Values*
Anthropometric Status → of Hypertension-Related Needs	-0.225	0.101	2.280	0.013*
Anthropometric Status → of Stoke Family History	0.348	0.069	5.363	0.000*
Anthropometric Status → Status of Blood Glycosis	-0.375	0.131	2.885	0.002*
Socioeconomic Status →of Hypertension-Related Needs	0.687	0.105	6.800	0.000*
Socioeconomic Status→ Status of Blood Glycosis	-0.372	0.154	2.688	0.008*
Stoke Family History→ Formal Education Level	0.396	0.128	5.363	0.001*

** Significant at $p < 0.05$ (two-tailed)
**Significant at $p < 0.10$ (one-tailed).

As shown in Table 4, the results of the structural pathway analysis indicated that anthropometric status had a significant negative effect on blood glucose status (β = –0.375; p = 0.002). This suggests that individuals with better anthropometric profiles—representing healthier nutritional status and body composition—tend to have lower blood glucose levels. Similarly, socioeconomic status was negatively associated with blood glucose (β = –0.372; p = 0.008), implying that respondents with higher socioeconomic conditions exhibited better glycemic control. These findings highlight the influence of social and nutritional inequalities as critical determinants of metabolic outcomes in stroke survivors residing in coastal areas.

In addition, anthropometric status showed a significant positive association with family history of stroke (β = 0.348; *p* = 0.000), indicating a potential clustering of stroke-related risk factors within families sharing both genetic and lifestyle patterns. Formal education level was also positively correlated with family history of stroke (β = 0.396; *p* = 0.001), suggesting that higher educational attainment may coincide with increased awareness and diagnosis, or reflect broader trends related to the epidemiological transition in which modern lifestyles elevate cardiovascular risk even among educated populations.

Furthermore, socioeconomic status exhibited a strong positive relationship with hypertension-related needs (β = 0.687; *p* = 0.000), suggesting a higher prevalence of hypertension among those with greater economic means, possibly due to sedentary behavior and dietary shifts. Conversely, anthropometric status negatively affected hypertension-related needs (β = –0.225; *p* = 0.013), reinforcing the protective role of optimal nutritional status. These structural relationships confirm that the interaction between socioeconomic conditions, education, nutrition, and family history plays a pivotal role in shaping metabolic risk and hypertension, ultimately influencing blood sugar regulation and the management of stroke risk in coastal communities.

The Hypercholesterolemia, Hypertension, and Hyperglycemia Problem Circle: A Portrait of Stroke Management Failures in Coastal Communities

Table 5. The Hypercholesterolemia, Hypertension, and Hyperglycemia Problem Circle: A Portrait of Stroke Management Failures in Coastal Communities

	Original Sample (O)	*Standard Deviation (STDEV)*	*T Statistics (|O/STDEV|)*	*P Values*
Comprehensive Clinical Needs (cholesterol levels and blood pressure) → Stroke Disease Management	0.844	0.072	11.675	0.000*
Comprehensive Clinical Needs → of the Risk Response System (access to health services and blood sugar levels)	0.487	0.121	4.351	0.000*
Stroke Disease Management →System Response to Risk	-0.303	0.104	2.861	0.002*
Stroke Disease Management → Status of Blood Glucose	-0.188	0.127	1.505	0.071*
Status of Blood Glycosis → System Response To Risk	0.911	0.087	12.462	0.000*
Stoke Family History → Stroke Disease Management	0.173	0.132	1.328	0.096*
Hypertension-Related Needs → Stroke Disease Management	-0.301	0.156	2.075	0.027*

As presented in Table 5, the analysis demonstrated that comprehensive clinical needs, which were represented by elevated cholesterol levels and systolic blood pressure, had a strong positive effect on both stroke disease management (β = 0.844; *p* = 0.000) and the system's response to risk (β = 0.487; *p* = 0.000). This finding suggests that as patients' clinical conditions become more severe, health systems tend to respond more actively, potentially through intensified monitoring, intervention, or referral pathways. Moreover, the severity of clinical needs may also motivate individuals to improve their self-management practices, thus reinforcing the dual role of clinical severity in prompting both institutional and individual-level responses to stroke risk in coastal populations.

Interestingly, there are two contrasting relationship patterns related to family history. First, family history of stroke showed a tendency to have a positive association with stroke management (β = 0.173; p = 0.096), but in the field and coastal contexts, it was found that respondents with a family history of stroke tended to have poorer stroke management skills. This phenomenon is suspected to be influenced by psychosocial factors such as excessive fear, anxiety, health fatalism, and low stroke management practices in previous families.

In contrast, a family history of hypertension showed a significant positive influence on stroke disease management (β = 0.687; p = 0.000). These findings show that respondents who have family members with hypertension actually have better ability to manage stroke disease. It can be explained that family experiences in dealing with previous hypertension, including blood pressure monitoring habits, dietary control, and health service visits, provide protective and educational effects for respondents in dealing with stroke.

In addition, stroke disease management has a significant negative effect on the system's response to risk (β = -0.303; p = 0.002), indicating that poor stroke management is the main factor in increasing the burden on health services, including the high number of visits to health centers. Meanwhile, blood glucose status also showed a very strong positive influence on the system's response (β = 0.911; p = 0.000), reinforcing evidence that the health system only reacts when a patient's blood sugar levels are already high. The association between stroke management and blood glucose reduction remained insignificant (β = -0.188; p = 0.071), indicating that improvements in blood sugar levels were more due to health system interventions, rather than the result of self-management by stroke patients.

Causality Models and Strategies for Improving the Quality of Stroke Management in Coastal Communities

As illustrated in Figure 1, the results of the causality model analysis revealed that the quality of stroke disease management can be explained by several key constructs, with an R-Square value of 0.754. This indicates that 75.4% of the variance in stroke management is accounted for by variables included in the model, namely comprehensive clinical needs, blood glucose status, and the system response to risk. The relatively high R-squared value demonstrates that the model possesses strong predictive power, confirming its adequacy in describing the dominant factors that influence stroke management among populations in coastal regions.

Specifically, the main findings suggest that comprehensive clinical needs (based on cholesterol levels and systolic pressure) are the most dominant driving factors for improved stroke management (β = 0.844; p = 0.000). However, the paradox. The system's response to risk is triggered by poor stroke management (β = -0.303; p = 0.002), as well as high blood glucose levels (β = 0.911; p = 0.000). This shows that the new health system responds actively after a patient's clinical condition deteriorates, not as a result of good disease management at the individual level.

Based on these findings, effective stroke management quality improvement strategies in coastal communities should be focused on strengthening the control of primary risk factors, such as cholesterol reduction, blood pressure control, and early blood sugar management, rather than relying solely on system responses after acute patient conditions. Community-based interventions that include routine screening, health education, strengthening nutritional literacy, and controlling hypertension and dyslipidemia are key. In addition, increasing early detection and regular monitoring of metabolic risk factors at health centers is also an important component in breaking the cycle of hypercholesterolemia, hypertension, and hyperglycemia problems that have been the main obstacles to the success of stroke management in coastal areas.

DISCUSSION

Descriptive Analysis of Respondent Characteristics

The results of this study show that the majority of stroke patients in coastal areas are men over 55 years old with low education levels and come from the middle to lower socioeconomic class. These findings are in line with studies by Loh et al. (2022) and Malaeb et al. (2021) which reported that sociodemographic factors such as old age, gender, low education, and low economic status are associated with high rates of stroke incidence and barriers to accessing health services [9,10]. Education also affects the incidence of hypertension [11]. The nutritional status of the patients in this study showed variation between undernourished and normal nutrition. In addition, biochemical examinations showed that most patients had high cholesterol and blood sugar levels. These findings reinforce the report of Clancy et al. (2023) which suggests that metabolic disorders such as hypercholesterolemia and hyperglycemia are common in stroke patients and can worsen functional status as well as quality of life [12]. The consumption of high-cholesterol and fat foods found in stroke patients in these coastal areas is also a concern, as explained by Haq et al. (2024) who highlight the adverse impact of a diet high in sodium and fat on the metabolic profile of stroke patients [13].

Based on these results, an integrated stroke management model with a community-based approach is needed. This model involves ongoing health education, strengthening the role of families in patient care, and improving access to primary and secondary health services. Malaeb et al. (2021) emphasize the importance of family support in the management of post-stroke risk factors, while Clancy et al. (2023) advocate multidisciplinary interventions that include regular monitoring of clinical parameters such as blood pressure, cholesterol, and blood sugar [10,12].

Additionally, the use of simple technology such as medication reminder apps and remote consultations can help patients stay connected to healthcare. Chang et al. (2022) also show that sociodemographic factors such as a patient's education level, income, and physical function play a significant role in determining the level of social participation and successful post-stroke community integration, so it needs to be a key consideration in the planning of community-based rehabilitation programs in coastal areas [14].

Overall, these findings confirm that improved stroke disease management in coastal areas requires a holistic and community-based approach that takes into account the sociodemographic characteristics of patients, nutritional status, and the metabolic factors underlying their condition. With the implementation of an integrated management model involving health education, metabolic risk factor control, family support, and sustainable health services, it is hoped that the quality of life of stroke patients in coastal areas can be significantly improved.

Social Inequality and Nutrition Fueling Blood Sugar Spikes: A Portrait of Double Risk Stroke Sufferers on the Coastal

The results of the analysis showed that anthropometric status and socioeconomic status had a significant negative relationship with blood glucose levels in stroke patients in coastal areas. The higher the anthropometric status of the respondent, which reflects better nutritional status and body composition, the lower the blood glucose level. Similarly, the higher the socioeconomic status of the respondent, the more controlled their blood glucose levels are. These findings are in line with the results of a study by Jamal et al. (2021) which showed that individuals with low socioeconomic status and poor nutritional status tended to have poorer blood glucose control.

Epidemiologically, these results show that groups with low socioeconomic status and undernutrition in coastal areas are priority populations in stroke complication prevention programs. Limited access to nutritious food, low health awareness, and lack of routine blood sugar monitoring facilities worsen blood glucose control. Song et al. (2022) in their study showed that nutritional status and blood glucose levels are important predictors of the occurrence of complications such as post-stroke pneumonia, which worsens the clinical prognosis[15].

The epidemiological management implications of these findings are the importance of strengthening early detection programs for hyperglycemia and malnutrition in stroke patients in coastal communities through a community-based screening approach. This program can be carried out through the involvement of health cadres, nutrition education, and primary health services that are able to monitor and intervene quickly in changes in blood glucose levels in stroke patients. Yao et al. (2023) also emphasize that effective control of post-stroke hyperglycemia requires integration between clinical and social factors, including strengthening family and community support in the management of chronic diseases [16].

Through a community-based epidemiological management approach that focuses on socioeconomic factors and nutritional status, it is hoped that blood glucose levels control among stroke survivors in coastal areas can be more optimal. This effort is important to reduce the risk of long-term complications and improve the quality of life of stroke patients in populations with limited access to health services.

The results of the analysis showed that formal education level had a positive correlation with a family history of stroke, suggesting that respondents with higher education had more family members who had had a stroke. These findings are in line with research by Yu et al. (2021) which reported that individuals with higher education have a higher risk of stroke in at-risk populations, likely due to sedentary lifestyles and consumption of high-fat foods [17]. Franc et al. (2021) also showed that in young populations with stroke, higher education levels may be related to unhealthy lifestyle behaviors such as lack of physical activity [18].

Socioeconomic status also showed a positive correlation with a history of hypertension, indicating that respondents with higher economic status tended to have a greater prevalence of hypertension. Stulberg et al. (2024) show that the prevalence of stroke at the population level is strongly correlated with socioeconomic factors such as poverty rates and access to health services, which may mediate the incidence of hypertension as a major risk factor for stroke in regions with varying socioeconomic levels [19].

Meanwhile, anthropometric status had a negative relationship with a history of hypertension, which meant that the better the nutritional status of the respondents, the lower their tendency to have a history of hypertension. Koval and Rey (2023) support these findings by showing that better nutritional status, particularly related to optimal body mass index, is associated with a lower risk of hypertension, while groups with low socioeconomic status and education show a higher risk of hypertension [20].

Epidemiologically, these findings confirm the importance of cardiovascular risk factor control strategies in coastal communities that consider the complex interactions between education, socioeconomic status, and nutritional status. Community-based interventions such as hypertension screening, equitable nutrition education at all levels of education, and promotion of healthy lifestyles are strategic steps in efforts to reduce the burden of primary and secondary strokes in vulnerable coastal areas.

The Hypercholesterolemia, Hypertension, and Hyperglycemia Problem Circle: A Portrait of Stroke Management Failures in Coastal Communities

The results of the structural model analysis showed that increased cholesterol levels and systolic blood pressure were the main factors that worsened the clinical condition of stroke patients in coastal areas. The high elevation of these two parameters indicates a high metabolic risk burden in stroke patients, which drives increased visits to primary health care facilities such as health centers. Luo et al. (2022) reported that increased cholesterol levels, particularly triglyceride-rich lipoprotein fractions, were significantly associated with the risk of diabetes mellitus in stroke patients, suggesting the presence of a complex interaction between dyslipidemia and hyperglycemia in this population [21]. In addition, Das et al. (2022) showed that prediabetes, dyslipidemia, and significantly elevated *levels of C-Reactive Protein* (CRP) were found in stroke patients, reinforcing the link between metabolic disorders and stroke incidence [22].

Although the number of healthcare visits is increasing, the quality of stroke management in coastal areas remains low, as demonstrated by the negative relationship between the system's response to risk and the quality of stroke management. This phenomenon suggests that health services in coastal communities are more curative and reactive, with the majority of patients accessing services only when clinical conditions have worsened. These findings are supported by Nowrin et al. (2023) in a systematic review showing that community-based interventions, including health education and community health worker engagement, are effective in lowering stroke risk factors such as blood pressure and cholesterol levels in resource-constrained countries [23].

Furthermore, high cholesterol levels and systolic pressure also contribute to increased blood glucose levels, which is thought to be through insulin resistance mechanisms and endothelial dysfunction due to chronic metabolic stress. Sugar levels have an effect on the increase in blood pressure [24]. Li et al. (2024) support this by showing that the triglyceride-glucose (TyG) index mediates the relationship between residual cholesterol and stroke incidence, indicating the importance of lipid and glucose control simultaneously in stroke populations [25]. Diets high in fat, low in fiber, and limited access to healthy foods in coastal communities exacerbate these metabolic disorders.

Epidemiologically, these findings reflect the paradox of health services in coastal areas, where the decline in blood glucose levels in stroke patients is more due to medical intervention after the condition has worsened, rather than the result of sustainable management of risk factors. This confirms the importance of a paradigm shift from curative management to community-based primary and secondary prevention. Health education programs, periodic monitoring of risk factors, and the integration of promotive and preventive services at health centers are strategic steps that need to be strengthened to improve the quality of stroke disease management in coastal communities.

Causality Models and Strategies for Improving the Quality of Stroke Management in Coastal Communities

The results of the causality model analysis showed that the quality of stroke management in coastal communities is strongly influenced by the patient's clinical condition and the reactivity of the health care system. The determination value ($R^2 = 0.754$) indicates that about 75% of the variation in stroke management can be explained by variables such as comprehensive clinical needs, blood glucose levels, and the system's response to risk. Unfortunately, the system responds more when the patient is already in a deteriorating condition, rather than during the early stages of risk control. This shows the dominance of reactive curative approaches, which actually weakens the effectiveness of tertiary prevention.

Tertiary prevention in epidemiology aims to prevent recurrence, complications, and long-term disability. In the context of stroke, this approach not only focuses on clinical treatment, but also involves restoring function, psychosocial support, and improving overall quality of life. However, the reality in coastal communities suggests that stroke patients are more likely to access the hospital only when they are acute, and rarely make regular visits or follow a consistent rehabilitation program. Maanoosi (2024) emphasized the need to build structured rehabilitation services in developing countries. Solutions include engaging families, leveraging low-cost technologies, and strengthening international collaboration for training and capacity building [26]. This illustrates structural inequalities in the provision of tertiary prevention services.

Strategies to improve the quality of stroke management in coastal areas should focus on integrated and sustainable community interventions. This scheme places the health center as a central point for screening and monitoring of risk factors such as blood pressure, cholesterol, and blood glucose, which is complemented by home visits, health education, and nutrition counseling. Community health workers or cadres play an important role in bridging patients' limited access to specialist services. The training program developed by Scheffler & Mash (2023) was shown to improve the ability of cadres to provide effective post-stroke care in patients' homes, including functional monitoring and psychosocial support [27]. This reinforces the argument that community-based interventions are not only realistic to implement in coastal areas, but also epidemiologically and economically effective.

Furthermore, the effectiveness of community management programs is also strengthened by *task-based self-rehabilitation* approaches, as proposed by Ibrahim et al. (2024). This model emphasizes functional and motor exercises that can be performed independently by patients at home with minimal supervision from family or health cadres. In addition to being cost-effective, this approach has been shown to increase patient recovery capacity in resource-constrained regions [28].

Thus, the ideal tertiary stroke prevention model in coastal communities must be based on integration between the primary service system (puskesmas), the role of community cadres, family support, and simple technologies such as teleconsultation. This model is able to answer the challenge of limited access, while improving the quality of life of stroke patients through continuous monitoring, education, and early intervention on recurrence.

Conclusion

The findings of this study suggest that the Stroke Disease Management model in coastal regions should place post-stroke care as a key component in community management. Policies directed at strengthening *home care services*, family education, repeated risk monitoring, and the development of simple rehabilitation facilities at the primary level are very relevant strategies in reducing the burden of disability due to stroke and improving the quality of life of stroke survivors in coastal areas

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