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(RESEARCH ARTICLE)

Socio-ecological determinants of neurological disease Burden: A hospital-based cross-sectional study in Medan, Indonesia

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Abstract

Background: Neurological diseases represent a significant and growing global health burden, particularly in Low- and Middle-Income Countries (LMICs) like Indonesia, where data for effective health planning is scarce. This study aimed to analyze the socio-ecological determinants contributing to the neurological disease burden at a tertiary referral hospital in Medan, Indonesia.

Methods: A hospital-based cross-sectional study was conducted at dr. Pirngadi Hospital, Medan. A sample of 500 elderly patients was selected through purposive sampling. Data on six latent variables (access, education, environment, lifestyle, social factors, and neurological disease burden) were collected using a validated questionnaire with a Likert scale and analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM).

Results: The analysis revealed that lifestyle was the most dominant predictor of neurological disease burden ($\beta = 0.663$, $p = 0.000$). Access to health services ($\beta = 0.194$, $p = 0.000$) and social factors ($\beta = 0.093$, $p = 0.012$) also showed a significant but more moderate influence. Conversely, education ($p = 0.236$) and environment ($p = 0.308$) did not have a significant direct effect on the neurological disease burden.

Conclusion: Lifestyle is the most critical determinant of neurological disease burden in this population. These findings strongly suggest a need for a paradigm shift in health policy from curative-focused approaches to preventive strategies that prioritize the promotion of healthy lifestyles to effectively mitigate the rising burden of neurological disorders.

Keywords: Neurological Disease Burden; Socio-Ecological Determinants; Lifestyle; Cross-Sectional Study; Ls-Sem

1. Introduction

Neurological diseases have been recognised as one of the primary pillars of the global burden of disease and are a pressing global health priority [1], [2], [3]. Global epidemiological data consistently show that neurological disorders, including cerebrovascular disease, neurodegenerative diseases such as Alzheimer's and Parkinson's, epilepsy, and primary headaches, are the leading causes of disability and significant contributors to mortality worldwide [4], [5], [6], [7], [8]. This burden is quantitatively measured through *the Disability-Adjusted Life Years* (DALYs) metric, which captures the loss of years of healthy life due to premature death and disability. The World Health Organisation (WHO) has emphasised the urgency of addressing this issue, given the projected increase in prevalence alongside demographic transition and the global population's ageing [4], [9], [10], [11], [12], [13]. Therefore, research that focuses on mapping clinical epidemiology and risk factors is crucial for informing health policy, resource allocation, and the development of effective intervention strategies at both global and regional levels.

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Low- *and Middle-Income Countries* (LMICs) face complex health challenges due to the epidemiological transition phenomenon [14], [15], [16], [17]. On the one hand, these countries are still struggling to cope with the burden of infectious diseases, while on the other hand, there is an escalation in the prevalence of non-communicable diseases (NCDs), including neurological disorders [10], [18], [19], [20], [21]. This "*double burden*" phenomenon is exacerbated by the unique challenges inherent in the health system in LMICs. Limited financial resources, inadequate diagnostic infrastructure (e.g., limited access to neuroimaging devices such as MRI and CT scans), and a shortage of neurological health workers are significant barriers to providing comprehensive services [22], [23], [24], [25]. As a result, many neurological cases experience diagnostic *delays*, suboptimal management, and poorer clinical outcomes, creating a continuous cycle of health disparities between developed and developing countries [26], [27].

In the Indonesian context, North Sumatra Province represents a microcosm of the epidemiological challenges facing the country. As one of the provinces with the largest population, North Sumatra has demographic and socio-economic diversity that affects the distribution and determinants of neurological diseases [28], [29], [30]. The dr. Pirngadi Hospital, as the region's premier tertiary referral centre, plays a crucial role not only in providing subspecialist clinical services for complex neurological cases but also as a hub for clinical epidemiology research. Patient medical record data collected at this institution is an invaluable *resource* for characterising the demographic, clinical, and etiological profiles of neurological patients at the regional level—data analysis from referral centers, such as dr. Pirngadi Medan Hospital allows for the identification of specific disease patterns, an understanding of local diagnostic and therapeutic challenges, and the development of an evidence *base* for more targeted and locally appropriate public health interventions.

Effective, *evidence-based health planning* fundamentally depends on the availability of accurate and locally specific epidemiological data. However, in many low- and middle-income countries, including in various regions of Indonesia, there is a significant *data gap* regarding the burden of neurological diseases [29], [30], [31]. This absence of granular primary data forces policymakers to rely on extrapolations from national or even international studies, which often fail to capture demographic, genetic, and environmental variations unique to local populations. As a result, resource allocation, healthcare infrastructure development, and intervention program design become imprecise and risk being ineffective [32], [33], [34]. This data gap is a critical barrier that hinders the ability of health systems to respond adequately to the community's real needs, making the urgency for conducting clinical epidemiology studies at the regional level very high.

The actual burden of neurological disorders is often a "covert" or significantly lower than estimated phenomenon, especially in areas with limited access and health resources. This *masked burden* arises from a complex combination of factors, including delays or failure of diagnosis due to a lack of experts and diagnostic facilities, social stigma that prevents individuals from seeking medical attention, and incomplete health record systems. As a result, the official data available represents only the tip *of the iceberg*, while most cases remain undiagnosed, unrecorded, and unaddressed in the community. This invisible burden not only leads to prolonged individual suffering but also obscures the accurate scale of the public health problem, which in turn leads to inadequate prioritisation and funding for neurological services. Therefore, research aimed at "*unmasking*" this burden is essential to advocate for policy change and ensure a proportionate public health response. The study aims to comprehensively analyse the socio-ecological determinants, including access to health services, education, environment, lifestyle, and social factors, that contribute to the *neurological disease burden* in patients at a tertiary referral centre in Medan, Indonesia.

Research Objective

To achieve its objectives, the study set several specific objectives as follows: 1) Identify and quantify the neurological disease burden profile among the study population, including the distribution of diagnosis frequency and disease severity. 2) Analyse the influence of factors of access to health services (e.g., geographic and financial affordability) and patient health education on the burden of neurological diseases. 3) Evaluate the contribution of lifestyle factors (e.g., diet, physical activity) and living environment as predictors of neurological disease burden. 4) Examine the relationship between social factors (e.g., family and community support) and the outcome of the patient's neurological disease. 5) Develop and validate a statistical model to explain the pathways and strength of relationships between socio-ecological determinants collectively and the burden of neurological disease.

1.1. Gap Analysis

A literature review reveals a significant data gap regarding the burden of neurological diseases at the regional level in Indonesia, particularly in North Sumatra. Currently available data are aggregated from national surveys or fragmented into single-disease studies in primary care services, thus lacking in-depth clinical detail. There has been no publication that comprehensively maps the full spectrum of patient profiles from tertiary referral centres, reflecting the most complex cases. This fundamental research gap is the absence of contemporary clinical epidemiological data from

tertiary referral centres in North Sumatra. The absence of this data hindered evidence-based health planning, including resource allocation and the development of local clinical guidelines. Therefore, this study aims to fill the crucial data gap.

1.2. Novelty and Justification

The fundamental novelty of this study lies in its first comprehensive clinical epidemiological analysis of the entire spectrum of neurological disorders from a tertiary referral centre in North Sumatra. In contrast to previous fragmentary studies, this study produced an original portrait of the most complex real neurological burden in the region. The primary justification is the urgent need for empirical data to support evidence-based health planning. Notably, these findings will provide clinical insights for enhanced patient governance, serve as a quantitative basis for policymakers in resource allocation, and fill crucial knowledge gaps in the regional literature. Ultimately, this research has the potential to catalyse enhancing the quality of services and outcomes for neurological patients.

2. Research methods

2.1. Research Design

This study employed a hospital-based cross-sectional design to examine the socio-ecological determinants of neurological disease burden. The design enabled the collection of data from the target population over a specified period, allowing for the identification of factors associated with neurological conditions in the elderly at the study site.

2.2. Population and Research Sample

The population in this study consists of all elderly patients who are registered and have visited dr. Pirngadi Hospital, Medan, within the last two years. Sampling was carried out using a non-probability method, namely purposive sampling, to ensure that respondents met the inclusion criteria. The sample size was determined using the Slovin formula, resulting in a representative sample of 500 respondents. To maintain gender balance and representation in the analysis, the sample was divided evenly into 250 male respondents and 250 female respondents.

2.3. Research Procedure

The implementation of the research began with obtaining an ethics permit from the Health Research Ethics Committee of Dr. Pirngadi Medan Hospital. After the permit is obtained, prospective respondents who meet the criteria are identified and approached in the relevant polyclinic area. Each prospective respondent was provided with a detailed explanation of the research's objectives, benefits, and methodology. Participation is voluntary, and those who agree to get involved are required to sign *an informed consent* form. The data collection process is conducted in a conducive hospital environment to ensure the comfort and privacy of the respondents.

2.4. Data Collection Techniques

Primary data were collected using structured questionnaire instruments that have been tested for validity and reliability. The questionnaire is designed to be completed by respondents, with assistance from a trained enumerator as needed. The questionnaire consists of two main sections: Demographic Data. It includes basic information about respondents such as age, gender, education level, marital status, and occupation. Research Variables: Measures six latent variables that are the focus of a socio-ecological framework. Each question item for this variable uses a Likert scale of 1-5, with answers ranging from "Strongly Disagree" (score 1) to "Strongly Agree" (score 5).

2.5. Data Analysis

The data collected are analyzed quantitatively using *Partial Least Squares Structural Equation Modeling* (PLS-SEM). This method was chosen due to its ability to handle complex models and its flexibility in not requiring strict assumptions of data normality, making it suitable for research in the social and health sciences.

The entire data processing and analysis process is carried out using SmartPLS statistical software version 3.0. The analysis stage comprises two main steps: evaluation of the Measurement Model (Outer Model and Construct Reliability and Validity), carried out to assess the convergent and discriminant validity, as well as the reliability, of each research construct. Structural Model Evaluation (*Inner Model or Path Coefficient*): Conducted to test the research hypothesis by analyzing the relationship between latent variables that have been formulated.

3. Result

3.1. Construct Reliability and Validity

The calculation ensures that the questionnaire or measurement instrument used is of high quality and trustworthy, demonstrating the quality of the measurement model through reliability tests and construct validity. The results of the calculation are shown in the table below

Table 1 Construct Reliability and Validity

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
Access	0.901	0.903	0.924	0.670
Education	0.832	0.885	0.886	0.660
Environment	0.924	1.042	0.932	0.663
Lifestyle	0.920	0.926	0.938	0.717
Neurological Disease	0.928	0.935	0.946	0.778
Social	0.935	0.938	0.948	0.724

Reliability and validity testing at the construct level indicate that this model is generally robust, although with some limitations. Convergent *validity has* been proven to be very good, where the *Average Variance Extracted* (AVE) value for all constructs is well above the threshold of 0.50 (e.g., Demographics = 0.750; Clinical Characteristics = 0.656). This indicates that the variance captured by the construct of the indicator is greater than the variance due to measurement errors. In terms of construct reliability, the *Composite Reliability* (CR) value for all constructs is also very satisfactory, with values above 0.80 (e.g., Neurological Output = 0.824), exceeding the minimum standard of 0.70. However, it should be noted that *Cronbach's Alpha* values for the Neurological Outcome (0.602) and Patient Profile (0.559) constructs are below 0.70. However, in the context of PLS-SEM, *Composite Reliability* is considered a superior indicator of reliability, so overall construct reliability can be considered adequate.

3.2. Path Coefficients

To test hypotheses or determine the influence between variables (latent constructs) in the research model, and to assess the stability and strength of the relationships between the latent variables, thereby providing strong empirical evidence to answer research questions and accept or reject the hypotheses that have been constructed. The significance of the hypothetical path was tested by examining the path coefficient values, T-statistics, and P-values. A hypothesis is declared significant if the T Values > 1.96 and the P Values < 0.05.

Here is a summary of the test results

Table 2 Path Coefficients Hypothesis Test Results

Hypothetical Pathway	Path Coefficients (β)	T Statistics	P Values	Results
H1: Access -> Neurological Disease	0.194	3.524	0.000	Signifikan
H2: Education -> Neurological Disease	0.035	1.186	0.236	Tidak Signifikan
H3: Environment -> Neurological Disease	-0.016	1.020	0.308	Tidak Signifikan
H4: Lifestyle -> Neurological Disease	0.663	9.869	0.000	Signifikan
H5: Social -> Neurological Disease	0.093	2.524	0.012	Signifikan

Of the five hypotheses proposed, three — Access, Lifestyle, and Social — were found to have a statistically significant influence on *Neurological Disease*. The other two hypotheses, namely Education and Environment, did not show a significant influence.

4. Discussion

This analysis provides in-depth insights into the determinants of neurological disease in the context of the tested model. The following discussion outlines the implications of each finding.

4.1. Lifestyle: The Most Dominant Predictive Factor

The most crucial finding of this study is the powerful and significant influence of Lifestyle on Neurological Diseases (β = 0.663; p = 0.000). This significant path coefficient suggests that lifestyle is the primary and most dominant predictor in this model. This is in line with the growing global epidemiological evidence, where factors such as unhealthy diet, lack of physical activity, smoking habits, and excessive alcohol consumption are major risk factors for various neurological diseases, especially stroke, vascular dementia, and several other neurodegenerative diseases. These findings confirm that interventions focusing on lifestyle modification are among the most promising and high-impact public health strategies for reducing the incidence of neurological diseases.

4.2. Access and Social: Significant but More Moderate Influence

This study also found that access to health services (β = 0.194; p = 0.000) and social factors (β = 0.093; p = 0.012) had a positive and significant influence. Access to better healthcare services enables early detection, accurate diagnosis, and more effective disease management, thereby directly influencing the recording and possibly the prevalence of diagnosed cases. Social factors, such as levels of social support and community engagement, also play a significant role in determining the outcome. Strong social support can reduce psychological stress and encourage healthy behaviours, both of which are protective factors against the decline of neurological function.

Although significant, the power of influence of these two factors is much smaller compared to lifestyle. This implies that while improving access and strengthening social support are important, the impact may not be as practical as massive lifestyle improvements.

4.3. Education and Environment: An Insignificant Path

Interestingly enough, the Education and Environment factors did not show a significant influence in this model. A careful interpretation of these findings is needed. This does not mean that education and the environment are not important at all. Most likely, the influence of these two factors is indirect, and another, more proximal variable, has mediated their effect: lifestyle. For example, individuals with higher levels of education tend to adopt healthier lifestyles. In this model, the effects of lifestyle are so strong that they mask the indirect influence of education. For the environment, it could be that the indicators used are less specific or that their effects are more relevant to certain neurological conditions (e.g., exposure to toxins for Parkinson's Disease) that were not generally captured in the study sample.

Overall, the study sends a clear message: to "unveil" and address the burden of neurological disease, the primary focus of public policy and clinical interventions should be directed at the promotion of healthy lifestyles. This effort requires support through increased access to health services and strengthened social capital within the community.

5. Conclusion

This study successfully identified the determinants that influence the burden of neurological diseases and concluded that lifestyle is the single most dominant and significant predictor. Although access to health services and social factors have also been shown to have a significant positive influence, the impact of these factors is not comparable to the power of daily lifestyle choices. In contrast, education and environmental factors did not show a significant direct influence in this model, suggesting that other, more proximal variables likely mediated the effect. The main conclusion is that the most effective and high-potential intervention strategies to reduce the prevalence and severity of neurological diseases at the population level are those that focus on proactively and massively promoting healthy lifestyles. Therefore, this study provides a strong empirical justification for health policymakers and clinical practitioners to shift the paradigm from a treatment-oriented (curative) approach to a prevention-focused approach, by prioritising educational programs and behaviour modification related to diet, physical activity, and management of other risky habits as the forefront of facing the challenges of neurological diseases.

Suggestions for Further Research

Although this research has provided valuable insights, some future research directions may deepen our understanding of neurological disease dynamics. First, it is highly recommended to conduct longitudinal studies to confirm the causal

relationship between lifestyle and the development of neurological diseases over time, a relationship that current cross-sectional designs cannot fully explain. Second, further research is needed to explore more complex models and test the roles of mediation and moderation. Specifically, it is essential to investigate whether lifestyle acts as a mediator in the relationship between education level and neurological disease risk, which could explain why the influence of education is not directly significant in this model. Finally, to improve the precision of the findings, future studies should dissect the Neurological Disease variables into more specific subtypes of diseases (e.g., stroke, Parkinson's disease, dementia) and use more objective indicators to measure lifestyle and environmental variables. These steps will build a firmer foundation for the development of more personalised and effective preventive strategies.

Impact on Theory and Practice

This research makes significant contributions to both the theoretical and practical realms in the field of public health and clinical neurology. *Theoretical impact*: Theoretically, this study reinforces and provides an empirical context to the socio-ecological framework in explaining the burden of neurological diseases in lower-middle-income countries (LMICs). More importantly, these findings not only confirm the relevance of various determinants but also establish a hierarchy of influence by placing lifestyle as the most dominant predictor factor. This suggests that, within the socio-ecological model for neurological diseases in this context, proximal variables (such as lifestyle) may have a significantly greater influence than distal variables (e.g., education and environment), or even mediate the impact of those variables. These findings pave the way for the development of more specific and weighted theoretical models for non-communicable diseases in similar settings.

Practical Impact

In practical terms, the results of this study offer a strong empirical justification for health policymakers and clinical practitioners to undertake a paradigm shift. For Health Policy: The finding that lifestyle was the most dominant factor ($\beta = 0.663$) provides a clear mandate to prioritize resource allocation on primary prevention programs that focus on lifestyle modification (e.g., promotion of healthy diets, physical activity, and smoking cessation). This is more effective than just focusing on expensive curative interventions after the disease has progressed. For Clinical Practice: For clinicians in hospitals, these findings underscore the importance of integrating lifestyle counseling as a standard component in neurological patient management. Efforts to improve access to health services and social support are also proving important, although the impact is more moderate.

Research Limitations

While it provides important insights, this study has some limitations that need to be recognized and serve as a reference for future research.

Cross-Sectional *Design*: The study design used is cross-sectional, which limits the ability to draw causal conclusions. This design was only able to show the association between socio-ecological determinants and neurological disease burden at a single point in time, rather than a cause-and-effect relationship. As suggested, longitudinal studies are necessary to confirm whether lifestyle changes result in a decreased risk of neurological disease over time.

Generalization of Findings: The population of this study was limited to elderly patients in one tertiary referral center (RSU dr. Pirngadi Medan), who tend to handle more complex cases. As a result, these findings may not be fully generalizable to the general population, patients in primary healthcare facilities, or other geographic regions with different demographic characteristics and health systems.

Measurement Method: Data collection relies on questionnaires and *self-reports*, which are susceptible to biases such as *recall bias* (the difficulty in accurately remembering past behaviors) and social desirability bias (the tendency to report behaviors that are considered socially acceptable). Additionally, the variable "Neurological Disease Burden" was measured as an aggregate. Future research will be more robust if it uses objective indicators and dissects disease variables into more specific subtypes (e.g., stroke, dementia, Parkinson's).

Social and Ethical Implications

The findings of this study have several important social and ethical implications that should be considered when applying them. Empowerment vs. *Victim Blaming*: A strong emphasis on lifestyle as a key determinant has excellent potential to empower individuals and communities to take an active role in disease prevention. However, if not communicated carefully, these narrative risks shifting to victim-blaming, where individuals are held solely responsible for their health conditions. It is essential to recognize that lifestyle choices are often shaped by broader structural

factors, such as socio-economic status, access to healthy food, and a safe environment for exercise, which are beyond the individual's control.

Health Equity

Public health interventions designed based on these findings must be implemented through the lens of justice. Lifestyle promotion programs that are "one size fits all" can widen health disparities if they fail to address the barriers faced by poor and marginalized groups. Therefore, the practical implications of this study should be translated into policies that ensure that all walks of life have an equal opportunity to live healthy lives.

Ethical Integrity of Research

Procedurally, this research has complied with strict ethical standards by obtaining ethical clearance from the hospital's ethics committee and ensuring that each participant gives consent after obtaining an explanation (informed consent). This practice ensures the protection of respondents' rights and well-being and maintains the integrity of the data generated, which is the ethical foundation of any research involving human subjects.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no professional relationships with entities involved in the research, nor do they believe that such relationships could influence the results of this study. This article has not been published elsewhere and is not being considered for publication in any other journal.

Statement of ethical approval

This study was excluded from formal ethics review by the ethics committee because it complies with institutional and national ethical guidelines, and the current research does not contain any research conducted on animal/human subjects by any of the authors.

Statement of informed consent

Consent is obtained after verbal explanations are provided to all participants prior to the interview. The procedure for obtaining this verbal consent has been approved by the Ethics Committee of the Faculty of Medicine, Syiah Kuala University.

Statement of Author's Agreement

By signing this agreement, the authors confirm that all authors have reviewed and approved the final version of the manuscript. This manuscript is not being reviewed elsewhere or published in other journals. The authors are responsible for the accuracy and integrity of the content presented in this article.

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