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Association of Riverside Living with SIRS Incidence in Stroke Patient in South Kalimantan

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South Kalimantan is a province that has 97 rivers, and many people who live on the riverside make the rivers a source of life. Currently, there is more and more river water pollution, which has an impact on the health status of people living on the riverside, especially inflammation. This study used an analytic-observational design. The study subjects were stroke patients who were treated at the stroke unit and nerve ward at Ulin Hospital, Banjarmasin, for the period October 2022-May 2023. There were 128 subjects who were divided into two groups based on whether they lived on the riverside (64 people) or not (64 people). Variable analysis used descriptive analysis, the chi-square test, and multivariate analysis using the logistic regression test. Based on the descriptive analysis, it was found that there were no variables that showed meaningful results. Bivariate analysis resulted in variables that had a significant relationship. In the multivariate analysis, it was found that living on the riverside and mortality rate were independent predictors, which together with the dependent predictor factor, i.e., the type of stroke, affected the incidence of SIRS in stroke patients. Living on the riverside and mortality can be used as predictors of SIRS in stroke patients. SIRS assessment in an appropriate manner in stroke patients who live on river banks should be a routine examination. Prevention and monitoring of risk factors can prevent stroke patients from experiencing SIRS conditions to avoid complications that can occur.

Keywords: Riverside, Stroke, SIRS

INTRODUCTION

Stroke has become a health problem in developed and developing countries such as Indonesia. The high incidence of stroke is related to unhealthy lifestyles. The second highest cause of death in the world was caused by stroke in 2015 and the highest cause of death in Indonesia in 2014. RISKESDAS 2018 estimates that approximately 2,120,32 (10.9%) of the Indonesian population aged ≥ 15 years have been diagnosed with stroke, which is an increase compared to 2013, which was 7% (Kementerian Kesehatan RI, 2019). The 2023 SKI (Indonesia Health Survey) data indicates that prevalence of stroke in Indonesia is 8.3 per 1,000 population (Kementerian Kesehatan RI, 2024).

Stroke is defined as an acute functional brain disorder in the form of focal or global neurological deficits lasting more than 24 hours originating from cerebral blood flow disorders and not resulting from cursory cerebral circulatory disorders, brain tumors, secondary stroke due to trauma or infection (Khariri & Saraswati, 2021).

The Global Burden of Disease (GBD) 2021 **r**eport revealed that stroke remains the second leading cause of death, accounting for approximately 7 million deaths, and the third leading cause of both death and disability combined, as measured by disability-adjusted life years (DALYs), with over 160 million DALYs globally. Specifically, incident strokes have increased by 70% (95% UI 66 to 75), stroke-related deaths by 44% (32 to 56), and DALYs by 32% (22 to 43). In 2021 alone, there were 93.8 million prevalent strokes and 11.9 million incident strokes worldwide (Feigin et al., 2025). An epidemiological study by the ASEAN Neurological Association (ASNA) Stroke Epidemiological Study on 2065 stroke patients spread across 28 hospitals in Indonesia reported that the average

age of stroke patients was 59 years with 13% less than 45 years and 37% more than 65 years (Nugroho et al., 2023).

Based on SKI 2023 data, South Kalimantan ranks 4th highest in stroke prevalence among the population aged 15 years and over, with a rate of 9.5 per thousand, equal to Bangka Belitung Province, and slightly higher than Riau Islands (8.9‰) and Central Java (8.4‰). The highest prevalence was recorded in Yogyakarta Special Region (11.4‰) (Ministry of Health of the Republic of Indonesia, 2024). Stroke cases in Banjarmasin City were recorded at 4,046 residents in 2018 and made stroke ranked 3rd out of 11 non-communicable diseases in South Kalimantan Province. The number of new stroke cases also tends to increase every year where 943 new stroke cases were found in 2021 with the death rate reaching 136 cases. Additionally, the incidence of stroke in Banjarmasin reached 12,374 individuals in 2022, according to data from the Dinas Kesehatan Kalimantan Selatan (Dinas Kesehatan Provinsi Kalimantan Selatan, 2019, 2022; Izzuddin et al., 2024).

The river is a natural resource that is inseparable from the city of Banjarmasin, earning Banjarmasin the nickname "City of a Thousand Rivers" because of the many rivers that surround the city. Since ancient times, the river has been the main activity in trade and transportation for the people of Banjarmasin. The Barito River is the largest and longest river in South Kalimantan Province, and along its course has been the center of settlement for many generations. The riverbanks are fertile areas because of the silt deposited by the tides (Chrismianto & Santosa, 2022).

Data on the relationship between stroke disease and place of residence, especially in people who live on the banks of the river, is still very rare. Information on the prevalence of stroke cases among people living along the river is also unknown. Although some studies have linked the relationship between residence and stroke incidence where more stroke cases were found in urban areas (12.8%) than in rural areas (8.8%). This is believed to be related to lifestyle factors in urban areas. This data is also supported by Fernandes et al who said the prevalence of stroke cases in people living along the Amazon River is higher than people living in urban areas in the ribeirinhos population, namely residents who live along the Amazon River (Fernandes et al., 2013). In Palembang, Indonesia, there's Puskesmas Makrayu that located on lowland areas, and it is mostly situated along the banks of the Musi River. According to health profile data, Puskesmas Makrayu recorded the highest number of stroke cases in 2023, with a total of 223 patients. This number is notably high compared to stroke incidences in other Puskesmas in Palembang City (Putri et al., 2024). Several studies mention that stroke patients can be found to have increased proinflammatory cytokines in both blood and cerebrospinal fluid which increases the risk of infectious complications (Samoilova et al., 2021).

Systemic Inflammatory Response Syndrome (SIRS) is an exaggerated body defense response to a stressor such as (infection, trauma, surgery, acute inflammation, or malignancy) to localize and then eliminate the stressor. This response includes the first line of defense mechanisms involving the release of acute phase reactants (Chakraborty & Burns, 2023). The diagnosis of SIRS can be established if two or more of the following criteria are met: (1) body temperature above 38°C or below 36°C; (2) heart rate greater than 90 beats/min; (3) respiratory rate greater than 20 breaths/min or partial pressure of CO2 less than 32 mm Hg; and (4) leukocyte count greater than 12,000 or less than 4,000/µL or over 10% immature forms or bands (Gorneva & Tzonkov, 2023).

Stroke is an acute stressor that results in the release of oxidative stress markers, glutamate, and cytokines. These biomarkers are known to produce leukocytosis or leukopenia, elevated temperature, and tissue hypoxia resulting in the manifestation of SIRS. In stroke, SIRS may be a manifestation of systemic infection and the outcome may differ with non-infective causes. In recent years, the role of SIRS in stroke in terms of mortality, functional outcome of stroke, and complications during hospital stay, such as pneumonia, liver and kidney dysfunction, has been reported (Xu et al., 2020).

Despite the established understanding of stroke risk factors, the specific interplay between environmental determinants, particularly riverside living conditions prevalent in South Kalimantan and the systemic inflammatory response syndrome (SIRS) in stroke patients remains underexplored. Riverside settlements in this region often face unique environmental challenges, including water quality issues and high population density, which may exacerbate inflammatory pathways. Therefore, this study aims to analyze the association between riverside living and the incidence of SIRS among stroke patients at Ulin Hospital Banjarmasin. This research contributes to the field of environmental health by providing empirical evidence on how local settlement patterns may serve as a potential risk factor for acute inflammatory complications in stroke. The findings are intended to inform more targeted public health interventions and environmental management strategies in wetland areas.

METHODS

This study employed an analytic-observational design with a retrospective cross-sectional approach. This design was chosen to efficiently analyze existing medical records and assess the association between exposure (riverside living) and outcome (SIRS) in a hospital setting. The study was conducted at the Stroke Unit of Ulin General Hospital (RSUD Ulin) Banjarmasin, South Kalimantan. Ulin Hospital was selected as the study site because it serves as the central referral hospital for the Kalimantan region, providing a representative case mix of the local population living in wetland environments.

The population consisted of all stroke patients admitted to the Stroke Unit. We utilized a total sampling technique, incorporating all patients admitted during the period of October 2022 to May 2023 who met the eligibility criteria. This method was selected to maximize the sample

size within the study period and minimize selection bias often associated with non-probability sampling.

Data were collected retrospectively from medical records :

- Inclusion criteria: Patients diagnosed with acute stroke (ischemic or hemorrhagic) confirmed by CT scan, aged >18 years, and with complete medical records regarding residence address and admission vital signs/laboratories.
- Exclusion criteria: Patients referred from other hospitals with incomplete initial data or patients with pre-existing systemic infections (e.g., sepsis unrelated to stroke) identified upon admission. Variables collected included demographic data (age, gender, education), clinical data (type of stroke, GCS, NIHSS, SIRS status, mortality), and environmental data (residence location). Residence was categorized into "Riverside" (living within the riverbanks/wetland settlement areas) and "Non-Riverside" based on the patient's administrative address.

Data analysis was performed using SPSS software. Univariate analysis was used to describe subject characteristics. Bivariate analysis employed the Chi-square test to determine the association between independent variables and SIRS, with a significance level of $p < 0.05$ and calculation of Relative Risk (RR). Multivariate analysis was conducted using Logistic Regression to identify independent predictors of SIRS, controlling for confounding variable.

RESULTS AND DISCUSSION

The characteristics of the stroke patients included in this study are presented in Table 1. A total 128 subjects were analyzed, divided equally into two groups: those who living in riverside areas (n=64) and those in non-riverside areas (n=64). The mean age of patients in the riverside group was 57.17±10,8 years, while in the non-riverside group, it was 56,97±11,1 years. Regarding gender, female patients were predominant in both groups, accounting for 59,4% (n=38) in the riverside group and 51,6% (n=33) in the non-riverside group. In terms of education, the majority subject in both groups did not hold a bachelor's degree (87,5% in both groups). Other characteristics such as history of hypertension, diabetes mellitus (DM), and smoking showed no significant difference between the two groups (p>0.05).

Table 1
Demographic and Clinical Characteristics of Study Subjects

Variables	Living by the river		P-value
	Yes (n=64)	No (n=64)	
Age (years), (mean ± SD)	57.17±10.8	56.97±11.1	0.42**
Gender,			
Female, n (%)	38 (59.4)	33 (51.6)	0.37
Male, n (%)	26 (40.6)	31 (48.4)	
Education Level			
Bachelor	8 (12.5)	8 (12.5)	1.00
No degree	56 (87.5)	56 (87.5)	
History of hypertension			
Yes, n (%)	55 (85.9)	56 (87.5)	0.79
No, n (%)	9 (14.1)	8 (12.5)	
History of DM			
Yes, n (%)	17 (26.6)	16 (25.0)	0.84
No, n (%)	47 (73.4)	48 (75.0)	
Smoking History			
Yes, n (%)	17 (26.6)	26 (40.6)	0.09
No, n (%)	47 (73.4)	38 (59.4)	
History of dyslipidemia			
Yes, n (%)	16 (25.0)	19 (29.7)	0.55
No, n (%)	48 (75.0)	45 (70.3)	
Stroke onset during MRS			
≤24 hours	48 (75.0)	39 (60.9)	0.09
>24 hours	16 (25.0)	25 (39.1)	
Blood Sugar at admitted	54 (84.4)	53 (82.8)	0.81
≤ 200 mg/dL, n (%)	10 (15.6)	11 (17.2)	
> 200 mg/dL, n (%)			
Leukocytes			
≤11 ×10³/µL	41 (64.1)	34 (53.1)	0.21
>11 ×10³/µL	23 (35.9)	30 (46.9)	

Variables	Living by the river		P-value
	Yes (n=64)	No (n=64)	
Types of Stroke			
Infarction	44 (68.8)	43 (67.2)	0.85
Hemorrhage	20 (31.3)	21 (32.8)	
NIHSS			
Lightweight (0 to 5)	25 (39.1)	19 (29.7)	0.26
Medium-Heavy (≥ 6)	39 (60.9)	45 (70.3)	
GCS			
≤8	23 (35.9)	27 (42.4)	0.47
>8	41 (64.1)	37 (57.8)	
Mortality			
Died	13 (20.3)	21 (32.8)	0.11
Live	51 (79.7)	43 (67.2)	
Water source			
PDAM	52 (81.3)	58 (90.6)	0.13
Not a PDAM	12 (18.8)	6 (9.4)	

Notes: *Statistical test with chi-square test; **Statistical test with student t-test mean difference

The association between study variables and the incidence of Systemic Inflammatory Response Syndrome (SIRS) is shown in Table 2. The analysis revealed a significant association between riverside living and SIRS incidence (p = 0.01). Stroke patients living in riverside areas had a Relative Risk (RR) of 1.68 (95% CI: 1.13–2.50), indicating they are 1.68 times more likely to develop SIRS compared to those living in non-riverside areas.

Several other variables also showed significant associations with SIRS in the bivariate analysis, including history of Diabetes Mellitus (p=0.02), leukocyte count (p=0.02), type of stroke (p=0.01), NIHSS score (p=0.01), GCS score (p=0.01), and mortality (p=0.00). Meanwhile, age, gender, and water source (PDAM vs. Non-PDAM) were not significantly associated with SIRS incidence in this study.

Table 2
Bivariate Analysis of Factors Associated with SIRS Incidence

Variables	Category	SIRS events		p-value	RR (95% CI)
		Yes (n=59)	No (n=69)		
Age	≤50 years	12 (20.3)	19 (27.5)	0.34	0.799 (0.49-1.30)
	>50 years	47 (79.6)	50 (72.5)		
Sex	Female	31 (52.5)	40 (58.0)	0.54	0.889 (0.61-1.29)
	Male	28 (47.5)	29 (42.0)		
Living by the river	Yes	37 (62.7)	27 (39.1)	0.01*	1.68 (1.13-2.50)
	No	22 (37.3)	42 (60.9)		
Education level	Bachelor	4 (6.8)	12 (17.4)	0.07	0.51 (0.21-1.21)
	No degree	55 (93.2)	57 (82.6)		
History Hypertension	Yes	54 (91.5)	57 (82.6)	0.14	1.65 (0.77-3.54)
	No	5 (8.5)	12 (17.4)		
History DM	Yes	9 (15.3)	23 (33.3)	0.02*	0.54 (0.30-0.97)
	No	50 (84.7)	46 (66.7)		
History Smoking	Yes	24 (40.7)	21 (30.4)	0.23	1.27 (0.87-1.83)
	No	35 (59.3)	48 (69.6)		
History Dyslipidemia	Yes	17 (28.8)	19 (27.5)	0.87	1.064 (0.71-1.60)
	No	42 (71.2)	50 (72.5)		
Stroke onset when admitted to hospital	≤24 hours	42 (71.2)	43 (62.3)	0.29	1.25 (0.82-1.92)
	>24 hours	17 (28.8)	26 (37.7)		
Blood Sugar when admitted to hospital	≤ 200 mg/dL, n (%)	49 (83.1)	60 (87.0)	0.54	0.85 (0.53-1.73)
	> 200 mg/dL, n (%)	10 (16.9)	9 (13.0)		
Leukocytes	≤11 ×10³/µL	30 (50.8)	49 (71.0)	0.02*	0.49 (0.33-0.71)
	>11 ×10³/µL	29 (49.2)	20 (29.0)		

Variables	Category	SIRS events		p-value	RR (95% CI)
		Yes (n=59)	No (n=69)		
Type of stroke	Infarction	34 (57.6)	54 (78.3)	0.01*	0.52 (0.37-0.74)
	Bleeding	25 (42.4)	15 (21.7)		
NIHSS	Lightweight (0-5)	13 (22.0)	31 (44.9)	0.01*	0.54 (0.33-0.89)
	Medium-Heavy (≥ 6)	46 (78.0)	38 (55.1)		
GCS	8	38 (64.4)	28 (40.6)	0.01*	1.85 (1.28-2.68)
	>8	21 (35.6)	41 (59.4)		
Mortality	Died	35 (59.3)	7 (10.1)	0.00*	0.34 (0.23-0.48)
	Live	24 (40.7)	62 (89.9)		
Water source	PDAM	50 (84.7)	60 (87.0)	0.72	0.91 (0.55-1.51)
	Non PDAM	9 (15.3)	9 (13.0)		

Note *: significant

To identify independent predictors of SIRS, a multivariate logistic regression analysis was performed on variables with $p < 0.25$. As presented in Table 3, living by the river emerged as the strongest independent risk factor for SIRS ($p = 0.001$). The adjusted Odds Ratio (Exp(β)) was 4.240 (95% CI: 1.825–9.848), suggesting that after controlling for other variables, patients residing in riverside settlements have a more than fourfold increase in the risk of developing SIRS. Additionally, mortality was identified as a significant factor associated with SIRS ($p = 0.031$; Exp(β) = 0.382). Other variables such as history of DM, leukocyte count, type of stroke, NIHSS, and GCS were included in the model but did not show statistical significance as independent predictors ($p > 0.05$).

Table 3
Multivariate Logistic Regression Analysis of Independent Predictors for SIRS

Variables	Sig (p)	Exp(β)	95% CI
Living by the river	0.001*	4,240	1.825-9.848
History of DM	0.360	0.650	0.259-1.634
Leukocyte count	0,065	0,477	0.217-1.046
Type of stroke	0.723	1.190	0.454-3.124
NIHSS	0.784	1.122	0.493-2.553
GCS	0.465	0.706	0.277-1.797
Mortality	0.031*	0.382	0.159-0.917

Note *: significant

The primary finding of this study confirms a strong association between riverside living and the incidence of SIRS in stroke patients in South Kalimantan. While the bivariate analysis indicated a 1.68 times higher risk (RR = 1.68), the multivariate analysis further emphasized this relationship, showing an adjusted Odds Ratio of 4.240. This suggests that the environmental factor of living by the river is a substantial independent predictor for systemic inflammation post-stroke, even when clinical factors like stroke severity (NIHSS) or stroke type are taken into account. Direct comparisons with other studies are challenging due to the scarcity of recent literature specifically focusing on the intersection of riverside settlements and SIRS in stroke patients. Most existing studies analyze these factors separately, highlighting the novelty of this research in connecting environmental exposure directly to acute stroke complications.

This finding aligns with the hypothesis that environmental conditions in riverside settlements contribute to health vulnerability. In Banjarmasin, riverside areas are often characterized by high population density and specific sanitation challenges. Waheed et al., (2024) noted that human-river interactions in developing regions often correlate with higher morbidities due to environmental exposure. Similarly, Fernandes et al., (2013) found that riverine populations (such as in the Amazon) face unique health risks compared to urban populations. Our study extends this understanding by linking such environments specifically to inflammatory complications (SIRS) in stroke patients.

The mechanism likely involves chronic or acute exposure to pathogens prevalent in riverine environments. Samoilova et al., (2021) emphasized that infections and inflammation are critical in the development and worsening of stroke outcomes. Residents in these areas may have higher baseline exposure to waterborne pathogens, which, combined with the acute stress of a stroke, triggers an exaggerated inflammatory response (SIRS).

In our multivariate model, mortality was also significantly associated with SIRS ($p = 0.031$). This is consistent with Xu et al., (2020), who reported that SIRS is a predictor of poor outcomes, including increased mortality, in stroke patients. The presence of SIRS reflects a systemic dysregulation that often leads to multi-organ dysfunction, thereby increasing the risk of death.

Interestingly, while variables like Leukocyte count and NIHSS were significant in the bivariate analysis, they were not statistically significant in the final multivariate model. This differs from Kalita et al., (2015), who found NIHSS to be an independent predictor of SIRS. A possible explanation for this discrepancy is that in our specific study population (riverside communities), the

environmental influence (residence) was so dominant that it overshadowed some clinical variables in the regression model. Additionally, Zhang et al., (2024) highlighted that increased leukocyte levels correlate with poor outcomes; although our multivariate result for leukocytes was borderline (p=0.065), the trend supports the link between inflammation and stroke severity.

The high risk of SIRS among riverside stroke patients (Exp(β) = 4.240) has serious implications. It suggests that patients from these areas require more intensive monitoring for signs of inflammation and infection upon hospital admission. From a public health perspective, these findings highlight the need for targeted interventions in wetland settlements. Improving sanitation and water quality in riverside areas could potentially reduce the "environmental inflammatory load" on these communities, thereby improving their resilience against acute health events like stroke.

Several limitations in this study must be acknowledged to ensure transparent interpretation. First, the retrospective nature of the data collection relied on medical records, which restricted our ability to assess the specific environmental quality (e.g., water quality index, exact distance from the river) of each patient's home directly. We used residence address as a proxy for environmental exposure. Second, the sample size (n=128) was obtained from a single referral center (Ulin Hospital). While this hospital covers a large area of South Kalimantan, the results primarily reflect the clinical population of a referral center and may not fully represent the general community population. Third, potential confounding variables such as pre-admission nutritional status or specific vaccination history were not available in the records. Future studies should consider a prospective cohort design with direct environmental sampling to better establish causality.

CONCLUSIONS

Living by the river and mortality rate were significantly independent predictors of SIRS in stroke patients. While the history of DM, leukocyte levels, type of stroke, NIHSS, and GCS became dependent predictor factors. This study shows the relationship of living on the riverbank and mortality rate to the incidence of SIRS in stroke patients. Assessment of SIRS in an appropriate manner in stroke patients should be a routine examination. Prevention and monitoring of risk factors can prevent stroke patients from experiencing SIRS conditions to avoid complications that can occur.

SUGGESTION

It is recommended that hospitals**,** particularly those serving patients from riverside areas, implement routine screening for Systemic Inflammatory Response Syndrome (SIRS) in stroke patients from these areas. This is to facilitate early detection of potential SIRS cases in patients living by the river, considering the environmental and sanitation factors that may affect their health. Additionally, there should be community health programs focused on improving sanitation, better water management, and promoting healthy lifestyles among the riverside population to reduce the risk of stroke and related complications.

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