



# Determinants of Routine Follow-Up Adherence among Stroke Patients in Indonesia: Analysis of the 2023 Indonesian Health Survey

Salwah Suardi \*, Muh. Afdhal, Rezki Ramdani

Departement of Health Administration Faculty of Sport and Health Sciences, Universitas Negeri Makassar, Indonesia

\*Email (corresponding author): [salwahsuardi@unm.ac.id](mailto:salwahsuardi@unm.ac.id)

**Abstract.** Stroke is a non-communicable disease with the highest disability and mortality burden in Indonesia. Routine follow-up adherence to health facilities is a key determinant of successful secondary prevention, yet its determinants from a health administration and service management perspective remain underexamined using nationally representative data in Indonesia. The study aims to analyze factors associated with routine follow-up adherence among stroke patients and to identify the most dominant factor. This quantitative cross-sectional study used secondary data from the 2023 Indonesian Health Survey (Survei Kesehatan Indonesia/SKI), individual and household modules, merged by household identity. The eligible population comprised 5,621 individuals ever diagnosed with stroke by a physician. The outcome was routine follow-up status (routine vs. non-routine). Analyses included chi-square testing at the bivariate level and binary logistic regression with backward elimination based on likelihood ratio tests at the multivariate level. A total of 2,740 respondents (48.7%) adhered to routine follow-up. At the bivariate level, 14 of 16 variables were associated ( $p < .25$ ) and were entered as multivariate candidates. The final model retained six independently significant variables: age group, education level, urban/rural residence, the type of facility most frequently used by the household, hospital availability in the district/city, and perceived congruence of services with patient expectations. The most dominant factor was higher education (Adjusted OR=2.33; 95% CI 1.91–2.84;  $p < .001$ ), followed by hospital use as the primary facility (Adjusted OR=2.06; 95% CI 1.76–2.39;  $p < .001$ ). Routine follow-up adherence among stroke patients is shaped by an interaction between individual predisposing factors (education) and structural enabling factors (utilization of and access to referral facilities), indicating the need for layered interventions at both the individual and health-system levels.

**Keywords:** Follow-Up Adherence; Stroke; Logistic Regression; Health Administration; Healthcare Utilization

## 1. Introduction

Stroke is one of the leading causes of death and disability worldwide. Data from the Global Burden of Disease (GBD) 2021 study indicate that stroke remains a major contributor to global disability-adjusted life years (DALYs), with a disproportionately higher burden in low- and middle-income countries, including Indonesia (GBD 2021 Stroke Risk Factor Collaborators, 2024). Metabolic risk factors, particularly hypertension, diabetes mellitus, and dyslipidemia, are among the largest contributors to the burden of cardiovascular diseases, including stroke, in Southeast Asia (Yoon & Bushnell, 2023). In Indonesia, GBD estimates indicate a consistent increase in both stroke prevalence and incidence over the past two decades, placing the country among those with a relatively high burden of cerebrovascular and cardiovascular disease compared with other ASEAN countries (Widyasari et al., 2023).

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Consistent with these global trends, stroke is nationally recognized as the non-communicable disease (NCD) associated with the highest level of disability and remains a leading cause of death in Indonesia.

As a chronic condition associated with long-term sequelae, stroke management does not end with acute hospital-based care but requires continuous follow-up through regular visits to healthcare facilities to prevent recurrent stroke, manage residual risk factors such as hypertension and diabetes, and monitor patients' functional recovery (Hidayat et al., 2021). However, several small-scale local studies in Indonesia have documented substantial variation in the proportion of stroke patients who fail to attend regular follow-up visits at healthcare facilities, indicating potential systemic gaps in the continuity of care for patients with chronic NCDs across different settings. Adherence to routine follow-up is an essential component of continuity of care, defined as the extent to which healthcare services are sustained and coordinated over time for patients with chronic conditions (Hu et al., 2020). From a health administration and healthcare management perspective, follow-up adherence should not be viewed solely as an individual patient behavior, but also as an indicator of the healthcare system's capacity to provide sustained access, effective referral mechanisms, and quality services that encourage patient retention (Tossaint-Schoenmakers et al., 2021). Failure to attend routine follow-up may directly increase the risk of recurrent stroke, deterioration of functional status, and healthcare expenditure resulting from potentially preventable hospital readmissions through regular monitoring at primary and secondary care levels (Sarfo et al., 2023; Castellano et al., 2022).

Despite the recognized importance of follow-up adherence, most studies examining follow-up or medication adherence among patients with NCDs in Indonesia remain small-scale, facility-based investigations, with a predominant focus on clinical and individual behavioral determinants (Nasution et al., 2022). Nationally representative research specifically examining determinants of routine follow-up adherence among stroke patients by integrating individual-level factors, including sociodemographic characteristics, with healthcare system factors, such as healthcare facility utilization, availability of referral hospitals, and household perceptions of service quality, remains limited in Indonesia. Andersen's behavioral model of healthcare utilization emphasizes that sustained healthcare utilization cannot be fully understood without integrating individual predisposing factors with enabling factors at the healthcare-system level (Xin & Ren, 2023; Krzyż et al., 2023; Mareike et al., 2021).

This research addresses this gap through three key contributions. First, it is among the first analytical studies in Indonesia to specifically examine determinants of routine follow-up adherence among stroke patients using data from the 2023 Indonesian Health Survey (Survei Kesehatan Indonesia [SKI]) at the national population level, rather than relying on a single-facility case study. Second, the study integrates individual- and household-level data to construct measures of healthcare facility access and service quality, variables that are rarely available simultaneously within a single unit of analysis in previous studies. Third, the study explicitly adopts a health administration and healthcare management perspective rather than focusing exclusively on clinical determinants, thereby enhancing the relevance of its findings for managerial decision-making by healthcare facility administrators and health policymakers.

Accordingly, this study aims to: (1) describe the characteristics of stroke patients and the pattern of adherence to routine follow-up at healthcare facilities; (2) examine the

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associations between predisposing characteristics, individual enabling characteristics, area-level characteristics, and household-level healthcare facility utilization and service quality characteristics and routine follow-up adherence among stroke patients; and (3) identify the factors most strongly associated with routine follow-up adherence after controlling for potential confounding variables.

## 2. Methods

### 2.1 Study Design and Data Source

This study employed a quantitative approach using an observational analytical design with a cross-sectional framework to examine associations between variables at a single point in time without intervention. The study utilized secondary data from the 2023 Indonesian Health Survey (Survei Kesehatan Indonesia [SKI]), conducted by the Ministry of Health of the Republic of Indonesia in collaboration with Statistics Indonesia (Badan Pusat Statistik). The survey covered all 34 provinces in Indonesia, with households and individuals in both urban and rural areas serving as the units of analysis. Data analysis for the present study was conducted in 2026.

Field data collection for the 2023 SKI was conducted from August to the first week of October 2023, following a series of training sessions for provincial technical staff, district/city technical staff, and enumerators in July 2023 (World Health Organization Indonesia, 2024; Health Development Policy Agency, Ministry of Health of the Republic of Indonesia, 2024).

### 2.2 Study Population and Sample

The study population comprised all individuals who participated as respondents in the individual module of the 2023 SKI ( $n = 877,531$ ). The eligible population consisted of respondents who reported having ever been diagnosed with stroke by a physician (variable B24 = "Yes"), totaling 5,621 respondents. These respondents constituted the study sample through total sampling of the eligible population, rather than through an additional subsampling procedure.

The 2023 SKI itself employed a probability-based multistage stratified cluster sampling design, with strata and primary sampling units (PSUs) predetermined by the survey organizers. These design components are represented by the STRATA and PSU variables in the dataset. The survey also provides population sampling weights ( $w\_final$  for individuals and  $wrt$  for households) to account for differences in selection probabilities and non-response. Detailed information on the sampling frame and primary sampling procedures follows the official methodological documentation of the survey organizers. Because this study analyzed the entire eligible population, the sampling approach at the analytical stage was total sampling (census) of the 5,621 respondents with a history of stroke.

The primary analyses presented in Sections 3.2–3.3 did not incorporate the survey weight ( $w\_final$ ), strata, or PSU variables into the logistic regression models (unweighted analysis). Therefore, the reported odds ratios and confidence intervals represent associations within the study sample of stroke respondents rather than nationally representative estimates adjusted for the complex sampling design of the 2023 SKI. As a sensitivity analysis, the study also presents a survey-weighted logistic regression model incorporating  $w\_final$ , strata, and PSU (Section 3.4). Differences between the two analytical approaches are explicitly discussed as a limitation in Section 5.

## 2.3 Study Variables and Operational Definitions

The dependent variable was adherence to routine follow-up at healthcare facilities among stroke patients. Independent variables were grouped into four categories based on Andersen's Behavioral Model of Healthcare Utilization (Xin & Ren, 2023): (1) predisposing factors: age group, sex, and marital status; (2) individual-level enabling factors: educational attainment and employment status; (3) contextual/area-level enabling factors: urban/rural residence; and (4) household-level healthcare facility utilization, access, and service quality characteristics: the type of healthcare facility most frequently utilized by the household, availability of a hospital in the district/city, availability of disability-friendly services, and seven dimensions of perceived service quality, namely affordability/accessibility, completeness of facilities, low-cost/free services, staff friendliness, physical comfort, speed and appropriateness of services, and congruence of services with patients' expectations.

Detailed operational definitions, measurement scales, and categorization of each variable are presented in Table 1

**Table 1.** Operational Definitions of Study Variables

| Variabel                                       | Operational Definition                                                                                                 | Categories                                                                              | Scale   |
|------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|---------|
| <b>Routine follow-up adherence</b>             | Follow-up status of stroke patients at healthcare facilities based on respondents' self-report (SKI 2023 variable B26) | 1 = Routine; 2 = Not routine (occasionally/never)                                       | Nominal |
| <b>Age group</b>                               | Respondent's age at the time of interview, categorized into four groups                                                | <45; 45–59; 60–69; ≥70 years                                                            | Ordinal |
| <b>Sex</b>                                     | Respondent's sex                                                                                                       | Male; Female                                                                            | Nominal |
| <b>Marital status</b>                          | Respondent's marital status at the time of interview                                                                   | Never married; Married; Divorced; Widowed                                               | Nominal |
| <b>Educational attainment</b>                  | Highest level of education completed by the respondent                                                                 | Low (≤ primary school); Moderate (junior–senior high school); High (diploma–university) | Ordinal |
| <b>Employment status</b>                       | Respondent's economic activity status                                                                                  | Employed; Not employed                                                                  | Nominal |
| <b>Area classification</b>                     | Classification of the village/urban ward where the respondent resides                                                  | Urban; Rural                                                                            | Nominal |
| <b>Household's primary healthcare facility</b> | Type of healthcare facility most frequently utilized by the household during the previous year                         | Community health center (Puskesmas); Clinic/private practice; Hospital; None            | Nominal |

|                                                       |                                                                                                                                                   |                                                                                                                   |         |
|-------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|---------|
| <b>Availability of hospitals in the district/city</b> | Household's perception of the availability of a hospital in its area                                                                              | Available in the respondent's own district/city; Available in a nearby district/city; None available; Do not know | Nominal |
| <b>Disability-friendly services</b>                   | Perceived availability of services specifically designed for persons with disabilities at hospitals                                               | Yes; No; Do not know                                                                                              | Nominal |
| <b>Service quality dimensions (7 items)</b>           | Household assessment of accessibility, facilities, cost, staff friendliness, comfort, service speed, and congruence of services with expectations | Yes; No                                                                                                           | Nominal |

*Source: Indonesian Health Survey (Survei Kesehatan Indonesia [SKI]) questionnaire, individual and household modules, 2023*

## 2.4 Data Collection Instrument and Procedures

The data collection instruments used in this study were based on the standardized 2023 Indonesian Health Survey (Survei Kesehatan Indonesia [SKI]) questionnaires developed by the Ministry of Health of the Republic of Indonesia. The instruments consisted of a household questionnaire (covering healthcare facility access and service quality assessment) and an individual questionnaire (covering the history of non-communicable diseases, including stroke). No primary data were collected by the authors; instead, this study utilized secondary data obtained from these questionnaires.

The 2023 SKI instruments were developed by the Ministry of Health of the Republic of Indonesia in collaboration with Statistics Indonesia (Badan Pusat Statistik), with support from the World Health Organization and the World Bank in the development of the survey instruments, guidelines, and reporting procedures. The instruments underwent both internal validation, including tiered training for provincial, district/city technical staff, and enumerators, as well as supervision, monitoring, evaluation, and precision and accuracy measurement training, and external validation conducted by independent parties outside the Ministry of Health (Health Development Policy Agency, Ministry of Health of the Republic of Indonesia, 2024).

## 2.5 Research Ethics

This study used secondary data from the 2023 SKI, which had undergone an ethical clearance process during the data collection stage conducted by the survey organizers, including informed consent procedures for household and individual respondents prior to the interviews. The authors received the data in an anonymized form without personal identifiers that could directly identify respondents. Therefore, the confidentiality of respondents' data was maintained throughout the subsequent analytical process.

## 2.6 Data Analysis

Univariate analysis was performed to describe the frequency and proportion distributions of all categorical variables, as well as the mean and standard deviation for the

numerical variable (age). Bivariate analysis was conducted to examine the association between each categorical independent variable and the dependent variable using the chi-square test. Results were presented as crude odds ratios (ORs) calculated from contingency tables, 95% confidence intervals (CIs), and  $p$ -values. Variables with  $p < 0.25$  in the bivariate analysis were selected as candidates for multivariable analysis, following the principles of purposeful selection commonly applied in logistic regression modeling in epidemiological research.

Multivariable analysis was performed using binary logistic regression with backward elimination. All candidate variables were entered simultaneously into the initial model, after which the variable with the least statistically meaningful contribution (the highest  $p$ -value from the likelihood ratio test and  $p > 0.05$ ) was sequentially removed until a final model was obtained in which all retained variables were statistically significant ( $p < 0.05$ ). The likelihood ratio test was preferred over the Wald test for assessing the statistical significance of multilevel categorical variables. Regression results were presented as adjusted odds ratios (AORs), 95% CIs, and  $p$ -values. The variable with the highest statistically significant AOR was interpreted as the factor most strongly associated with routine follow-up adherence among stroke patients.

Observations with incomplete data on variables included in the model were excluded using a complete-case analysis approach; consequently, the number of observations in the final model ( $n=4,915$ ) was smaller than the eligible population ( $n=5,621$ ). All analyses were conducted using Python 3 with the *pandas*, *scipy.stats*, and *statsmodels* libraries. As a sensitivity analysis accounting for the complex sampling design of the 2023 SKI, a survey-weighted logistic regression analysis was also performed using the *w\_final*, STRATA, and PSU variables with Taylor linearization implemented through the Python *sampcls* library, as presented in Section 3.4.

An assessment of missingness across all 14 multivariable candidate variables showed that seven variables—age group, marital status, educational attainment, employment status, area classification, household's primary healthcare facility, and availability of a hospital in the district/city—had no missing data (0.0%). One variable, disability-friendly services, had 7.05% missing data (396 of 5,621 cases). Six service-quality assessment variables—affordability/accessibility, completeness of facilities, low-cost/free services, staff friendliness, physical comfort, and service speed—each had 6.35% missing data (357 of 5,621 cases). All missing values in these variables resulted from questionnaire skip patterns, whereby households without a regularly utilized healthcare facility were not asked to assess service quality.

Applying complete-case analysis across all candidate variables resulted in the exclusion of 706 of 5,621 cases (12.6%). A comparison of characteristics showed that the 706 excluded cases had a substantially lower proportion of routine follow-up adherence (31.6%) than the 4,915 cases retained in the final model (51.2%). More than half of the excluded cases (357 of 706) were from households whose primary healthcare facility was categorized as "None." This pattern suggests that the missing data were unlikely to be missing completely at random (MCAR) and may instead be associated with the outcome itself, consistent with a missing not at random (MNAR) mechanism. Consequently, the proportion of routine follow-up adherence observed in the final analytical sample may be overestimated relative to the overall eligible population. The implications of this potential selection bias are discussed further as a key limitation in Section 5.

### 3. Results and Discussion

#### 3.1. Result

##### 3.1.1. Respondent Characteristics and Routine Follow-up Adherence

Among the 5,621 respondents who had ever been diagnosed with stroke by a physician, 2,740 (48.7%) reported attending routine follow-up visits at healthcare facilities, whereas 2,881 (51.3%) reported attending follow-up only occasionally or not at all. The mean age of respondents was 61.0 years (SD 10.8; range 19–104 years), with those aged 45–59 years comprising the largest age group (38.8%). The majority of respondents were male (53.3%), married (77.1%), had low educational attainment (primary school or below) (51.7%), were employed (54.2%), and resided in urban areas (62.9%). Detailed respondent characteristics are presented in Table 2.

**Table 2.** Characteristics of Respondents and Routine Follow-up Adherence

| Variable                                   | Category                                              | n    | %    |
|--------------------------------------------|-------------------------------------------------------|------|------|
| <b>Routine follow-up adherence</b>         | Routine                                               | 2740 | 48.7 |
|                                            | Not routine                                           | 2881 | 51.3 |
| <b>Age group</b>                           | <45 years                                             | 338  | 6.0  |
|                                            | 45–59 years                                           | 2181 | 38.8 |
|                                            | 60–69 years                                           | 1913 | 34.0 |
|                                            | ≥70 years                                             | 1189 | 21.2 |
|                                            |                                                       |      |      |
| <b>Sex</b>                                 | Male                                                  | 2998 | 53.3 |
|                                            | Female                                                | 2623 | 46.7 |
| <b>Marital status</b>                      | Married                                               | 4333 | 77.1 |
|                                            | Widowed                                               | 1059 | 18.8 |
|                                            | Divorced                                              | 127  | 2.3  |
|                                            | Never married                                         | 102  | 1.8  |
| <b>Educational attainment</b>              | Low (≤primary school)                                 | 2908 | 51.7 |
|                                            | Moderate (junior–senior high school)                  | 2104 | 37.4 |
|                                            | High (diploma–university)                             | 609  | 10.8 |
| <b>Employment status</b>                   | Employed                                              | 3047 | 54.2 |
|                                            | Not employed                                          | 2574 | 45.8 |
| <b>Area classification</b>                 | Urban                                                 | 3534 | 62.9 |
|                                            | Rural                                                 | 2087 | 37.1 |
| <b>Household's<br/>healthcare facility</b> | <b>primary</b> Community health center<br>(Puskesmas) | 2578 | 45.9 |
|                                            | Clinic/private practice                               | 1538 | 27.4 |

|          |      |      |
|----------|------|------|
| Hospital | 1148 | 20.4 |
| None     | 357  | 6.4  |

Source: analysed from SKI 2023 data ( $n = 5,621$ ).

### 3.1.2. Bivariate Analysis

The results of the bivariate analysis examining the associations between all independent variables and routine follow-up adherence are presented in Table 3. Of the 16 variables analyzed, 14 showed an association with routine follow-up adherence at the  $p < 0.25$  threshold and were subsequently included as candidates for multivariable modeling, whereas sex and perceived affordability of healthcare costs did not meet this criterion. The highest crude ORs were observed for higher educational attainment (OR=2.89; 95% CI 2.41–3.47) and hospital utilization as the primary healthcare facility (OR=2.49; 95% CI 2.15–2.88). These findings indicate that respondents with higher educational attainment and those from households primarily utilizing hospitals had substantially greater odds of adhering to routine follow-up compared with their respective reference groups.

**Table 3.** Bivariate Analysis of the Association Between Independent Variables and Routine Follow-up Adherence Among Stroke Patients

| Variable (category)                          | n     | n (%) Routine Follow-up | OR   | 95% CI    | $p$    | Candidate |
|----------------------------------------------|-------|-------------------------|------|-----------|--------|-----------|
| <b>Age group</b>                             |       |                         |      |           |        |           |
| <45 years (ref)                              | 338   | 157 (46.4%)             | 1.00 | —         | —      | —         |
| 45–59 years                                  | 2,181 | 1,120 (51.4%)           | 1.22 | 0.97–1.53 | 0.094  | Yes       |
| 60–69 years                                  | 1,913 | 963 (50.3%)             | 1.17 | 0.93–1.47 | 0.188  | Yes       |
| ≥70 years                                    | 1,189 | 500 (42.1%)             | 0.84 | 0.66–1.07 | 0.150  | Yes       |
| <b>Sex</b>                                   |       |                         |      |           |        |           |
| Male (ref)                                   | 2,998 | 1,482 (49.4%)           | 1.00 | —         | —      | —         |
| Female                                       | 2,623 | 1,258 (48.0%)           | 0.94 | 0.85–1.05 | 0.271  | No        |
| <b>Marital status</b>                        |       |                         |      |           |        |           |
| Never married (ref)                          | 102   | 42 (41.2%)              | 1.00 | —         | —      | —         |
| Married                                      | 4,333 | 2,196 (50.7%)           | 1.47 | 0.99–2.19 | 0.059  | Yes       |
| Divorced                                     | 127   | 59 (46.5%)              | 1.24 | 0.73–2.10 | 0.424  | Yes       |
| Widowed                                      | 1,059 | 443 (41.8%)             | 1.03 | 0.68–1.55 | 0.898  | Yes       |
| <b>Educational attainment</b>                |       |                         |      |           |        |           |
| Low (≤primary school) (ref)                  | 2,908 | 1,174 (40.4%)           | 1.00 | —         | —      | —         |
| Secondary                                    | 2,104 | 1,163 (55.3%)           | 1.83 | 1.63–2.05 | <0.001 | Yes       |
| Higher                                       | 609   | 403 (66.2%)             | 2.89 | 2.41–3.47 | <0.001 | Yes       |
| <b>Employment status</b>                     |       |                         |      |           |        |           |
| Not employed (ref)                           | 2,574 | 1,199 (46.6%)           | 1.00 | —         | —      | —         |
| Employed                                     | 3,047 | 1,541 (50.6%)           | 1.17 | 1.06–1.30 | 0.003  | Yes       |
| <b>Area classification</b>                   |       |                         |      |           |        |           |
| Rural (ref)                                  | 2,087 | 874 (41.9%)             | 1.00 | —         | —      | —         |
| Urban                                        | 3,534 | 1,866 (52.8%)           | 1.55 | 1.39–1.73 | <0.001 | Yes       |
| <b>Household primary healthcare facility</b> |       |                         |      |           |        |           |

|                                                      |       |               |      |           |        |     |
|------------------------------------------------------|-------|---------------|------|-----------|--------|-----|
| Community health center (Puskesmas)<br>(ref)         | 2,578 | 1,172 (45.5%) | 1.00 | —         | —      | —   |
| Clinic/independent practice                          | 1,538 | 702 (45.6%)   | 1.01 | 0.89–1.14 | 0.910  | Yes |
| Hospital                                             | 1,148 | 775 (67.5%)   | 2.49 | 2.15–2.88 | <0.001 | Yes |
| None                                                 | 357   | 91 (25.5%)    | 0.41 | 0.32–0.53 | <0.001 | Yes |
| <b>Presence of hospital in district/city</b>         |       |               |      |           |        |     |
| Available in respondent's own<br>district/city (ref) | 4,756 | 2,355 (49.5%) | 1.00 | —         | —      | —   |
| Available in a nearby district/city                  | 469   | 245 (52.2%)   | 1.12 | 0.92–1.35 | 0.261  | Yes |
| None                                                 | 201   | 79 (39.3%)    | 0.66 | 0.50–0.88 | 0.005  | Yes |
| <b>Disability-friendly services</b>                  |       |               |      |           |        |     |
| No (ref)                                             | 98    | 42 (42.9%)    | 1.00 | —         | —      | —   |
| Yes                                                  | 4,523 | 2,302 (50.9%) | 1.38 | 0.92–2.07 | 0.117  | Yes |
| <b>Affordable access</b>                             |       |               |      |           |        |     |
| No (ref)                                             | 286   | 162 (56.6%)   | 1.00 | —         | —      | —   |
| Yes                                                  | 4,978 | 2,487 (50.0%) | 0.76 | 0.60–0.97 | 0.028  | Yes |
| <b>Complete facilities</b>                           |       |               |      |           |        |     |
| No (ref)                                             | 1,012 | 432 (42.7%)   | 1.00 | —         | —      | —   |
| Yes                                                  | 4,252 | 2,217 (52.1%) | 1.46 | 1.27–1.68 | <0.001 | Yes |
| <b>Low-cost/free services</b>                        |       |               |      |           |        |     |
| No (ref)                                             | 764   | 372 (48.7%)   | 1.00 | —         | —      | —   |
| Yes                                                  | 4,500 | 2,277 (50.6%) | 1.08 | 0.93–1.26 | 0.329  | No  |
| <b>Friendly staff</b>                                |       |               |      |           |        |     |
| No (ref)                                             | 742   | 340 (45.8%)   | 1.00 | —         | —      | —   |
| Yes                                                  | 4,522 | 2,309 (51.1%) | 1.23 | 1.06–1.44 | 0.008  | Yes |
| <b>Comfortable facilities</b>                        |       |               |      |           |        |     |
| No (ref)                                             | 872   | 405 (46.4%)   | 1.00 | —         | —      | —   |
| Yes                                                  | 4,392 | 2,244 (51.1%) | 1.21 | 1.04–1.39 | 0.012  | Yes |
| <b>Fast/appropriate services</b>                     |       |               |      |           |        |     |
| No (ref)                                             | 922   | 435 (47.2%)   | 1.00 | —         | —      | —   |
| Yes                                                  | 4,342 | 2,214 (51.0%) | 1.17 | 1.01–1.34 | 0.036  | Yes |
| <b>Services meet expectations</b>                    |       |               |      |           |        |     |
| No (ref)                                             | 884   | 384 (43.4%)   | 1.00 | —         | —      | —   |
| Yes                                                  | 4,380 | 2,265 (51.7%) | 1.39 | 1.21–1.61 | <0.001 | Yes |

### 3.1.3. Multivariable Analysis

Based on the 14 candidate variables, logistic regression modeling was performed using the backward elimination method. The stepwise elimination process removed eight variables that were not independently significantly associated with routine follow-up adherence: staff friendliness, employment status, facility comfort, disability-friendly services, affordable access, facility completeness, service speed, and marital status. The final model therefore comprised six variables, all of which were independently significantly associated with routine follow-up adherence (Table 4): age group, educational attainment, area classification, household primary healthcare facility, availability of a hospital in the district/city, and perceived congruence of services with patient expectations. The final model included 4,915 observations with complete data for all variables included in the model (complete-case

analysis) and showed a significant likelihood ratio test ( $p<0.001$ ) for the overall model fit, indicating that the model was statistically significant in explaining variation in routine follow-up adherence.

Based on the adjusted odds ratios (AORs) from the final model, the factor most strongly associated with routine follow-up adherence among stroke patients was higher education/tertiary education (AOR=2.33; 95% CI: 1.91–2.84;  $p<0.001$ ) compared with low educational attainment. This was followed by the use of a hospital as the household's primary healthcare facility (AOR=2.06; 95% CI: 1.76–2.39;  $p<0.001$ ) compared with use of a community health center (Puskesmas). Other factors that remained significantly associated with routine follow-up adherence, but with more moderate strengths of association, were secondary education (AOR=1.63), services meeting patient expectations (AOR=1.30), availability of a hospital in a nearby district/city (AOR=1.29), and urban residence (AOR=1.21).

**Table 4.** Results of Multivariable Binary Logistic Regression Analysis (Final Model after Backward Elimination,  $n=4,915$ )

| Variable                                                                            | Crude OR | Adjusted OR | 95% CI (AOR) | <i>p</i> -value |
|-------------------------------------------------------------------------------------|----------|-------------|--------------|-----------------|
| Age 45–59 years (vs. <45)                                                           | 1.22     | 1.26        | 0.98–1.62    | 0.075           |
| Age 60–69 years (vs. <45)                                                           | 1.17     | 1.21        | 0.94–1.57    | 0.144           |
| Age $\geq 70$ years (vs. <45)                                                       | 0.84     | 0.97        | 0.74–1.27    | 0.808           |
| Secondary education (vs. low)                                                       | 1.83     | 1.63        | 1.43–1.86    | <0.001          |
| Higher education (vs. low)                                                          | 2.89     | 2.33        | 1.91–2.84    | <0.001          |
| Urban residence (vs. rural)                                                         | 1.55     | 1.21        | 1.07–1.38    | 0.003           |
| Independent clinic (vs. Puskesmas)                                                  | 1.01     | 0.94        | 0.82–1.08    | 0.394           |
| Hospital (vs. Puskesmas)                                                            | 2.49     | 2.06        | 1.76–2.39    | <0.001          |
| Hospital in a nearby district/city (vs. hospital in respondent's own district/city) | 1.12     | 1.29        | 1.05–1.58    | 0.017           |
| Services meet patient expectations: Yes (vs. No)                                    | 1.39     | 1.30        | 1.11–1.52    | 0.001           |

AOR = adjusted odds ratio; CI = confidence interval. Overall model likelihood ratio test:  $p<0.001$ ; Pseudo  $R^2=0.048$ . Variables removed during backward elimination: marital status, employment status, disability-friendly services, affordable access, facility completeness, staff friendliness, facility comfort, and service speed (all  $p>0.05$  based on the likelihood ratio test).

### 3.1.4. Sensitivity Analysis: Survey-Weighted Logistic Regression

To evaluate the impact of the complex sampling design of the 2023 Indonesian Health Survey (SKI), including the survey weights ( $w_{\text{final}}$ ), stratification, and primary sampling units (PSUs), on the estimates obtained from the final model, a sensitivity analysis was conducted using survey-weighted logistic regression with Taylor linearization for variance estimation (using the Python *samplics* library). Because 125 of the 838 strata represented in the stroke case sample contained only one PSU, precluding variance estimation for these strata, a skip approach was applied to the singleton strata. This resulted in a sensitivity model comprising 4,780 observations, slightly fewer than the 4,915 observations included in the primary model.

The sensitivity analysis results (Table 5) showed that the direction and magnitude of the associations for higher education (weighted AOR=2.00; 95% CI: 1.41–2.85;  $p<0.001$ ), hospital use as the household's primary healthcare facility (weighted AOR=2.09; 95% CI: 1.62–

2.68;  $p < 0.001$ ), and urban residence (weighted AOR=1.28; 95% CI: 1.04–1.58;  $p = 0.018$ ) were relatively consistent with those of the primary unweighted model, supporting the robustness of the main findings. However, two estimates showed substantive changes. First, respondents aged  $\geq 70$  years were significantly less likely to adhere to routine follow-up (weighted AOR=0.58; 95% CI: 0.36–0.94;  $p = 0.026$ ), whereas this association was not statistically significant in the unweighted model (AOR=0.97;  $p = 0.808$ ). Second, the presence of a hospital in a nearby district/city was no longer independently associated with routine follow-up adherence (weighted AOR=0.91; 95% CI: 0.65–1.26;  $p = 0.568$ ), compared with the significant association observed in the primary model (AOR=1.29;  $p = 0.017$ ). These differences indicate that incorporating survey weights and accounting for the complex sampling design may affect the statistical conclusions for certain variables, as discussed further in Section 5 (Study Limitations).

**Table 5.** Comparison of the Primary Unweighted Logistic Regression Model and the Survey-Weighted Sensitivity Model

| Variable                                                                            | Primary Model<br>Unweighted ( $n=4,915$ ) |           |        | Sensitivity Model<br>Survey-weighted<br>( $n=4,780$ ) |           |        |
|-------------------------------------------------------------------------------------|-------------------------------------------|-----------|--------|-------------------------------------------------------|-----------|--------|
|                                                                                     | AOR                                       | 95% CI    | $p$    | AOR                                                   | 95% CI    | $p$    |
| Age 45–59 years (vs. <45)                                                           | 1.26                                      | 0.98–1.62 | 0.075  | 0.80                                                  | 0.51–1.25 | 0.332  |
| Age 60–69 years (vs. <45)                                                           | 1.21                                      | 0.94–1.57 | 0.144  | 0.77                                                  | 0.48–1.22 | 0.261  |
| Age $\geq 70$ years (vs. <45)                                                       | 0.97                                      | 0.74–1.27 | 0.808  | 0.58                                                  | 0.36–0.94 | 0.026  |
| Secondary education (vs. low)                                                       | 1.63                                      | 1.43–1.86 | <0.001 | 1.77                                                  | 1.43–2.18 | <0.001 |
| Higher education (vs. low)                                                          | 2.33                                      | 1.91–2.84 | <0.001 | 2.00                                                  | 1.41–2.85 | <0.001 |
| Urban residence (vs. rural)                                                         | 1.21                                      | 1.07–1.38 | 0.003  | 1.28                                                  | 1.04–1.58 | 0.018  |
| Independent clinic (vs. Puskesmas)                                                  | 0.94                                      | 0.82–1.08 | 0.394  | 0.88                                                  | 0.71–1.09 | 0.233  |
| Hospital (vs. Puskesmas)                                                            | 2.06                                      | 1.76–2.39 | <0.001 | 2.09                                                  | 1.62–2.68 | <0.001 |
| Hospital in a nearby district/city (vs. hospital in respondent's own district/city) | 1.29                                      | 1.05–1.58 | 0.017  | 0.91                                                  | 0.65–1.26 | 0.568  |
| Services meet patient expectations: Yes (vs. No)                                    | 1.30                                      | 1.11–1.52 | 0.001  | 1.45                                                  | 1.14–1.85 | 0.003  |

AOR = adjusted odds ratio; CI = confidence interval. The sensitivity model incorporated the SKI 2023 survey weight ( $w_{final}$ ), strata, and PSU, with variance estimated using Taylor linearization (Python *samplims* library). Of the 838 strata, 125 contained a single PSU and were handled using a skip approach, with the variance set to zero for these strata. Consequently, the sensitivity model included 4,780 observations, slightly fewer than the 4,915 observations in the primary model.

## 3.2. Discussion

### 3.2.1. Individual Predisposing Factors: Age, Sex, and Marital Status

Age group was significantly associated with routine follow-up adherence in the overall model ( $p = 0.0046$ ), although not all pairwise comparisons between age categories reached statistical significance at the 5% level. A non-linear pattern was observed, with the highest proportion of adherence among those aged 45–59 years (51.4%) and the lowest among those aged  $\geq 70$  years (42.1%). This pattern is consistent with findings from Cheng et al. (2025)

using the ENHANCE survey, which identified age as an important determinant of healthcare utilization in Indonesia, although the direction of the association varied according to the type of healthcare service. From a health administration perspective, one possible explanation is that older patients face greater physical mobility barriers and greater dependence on caregivers to access healthcare facilities, whereas younger patients may have lower awareness of the risk of stroke recurrence because they perceive their condition as relatively stable.

In contrast to age, sex was not significantly associated with routine follow-up adherence, either in the bivariate analysis (OR=0.94; 95% CI 0.85–1.05;  $p=0.271$ ) or as a candidate for multivariable analysis because it did not meet the  $p<0.25$  threshold. This finding differs from Cheng et al. (2025), who identified sex as a strong determinant of healthcare utilization in Indonesia, but is consistent with several studies of adherence to follow-up care for specific chronic diseases, suggesting that following the diagnosis of a severe condition such as stroke, urgent clinical needs (need factors) may overshadow the influence of gender-related predispositions on healthcare-seeking decisions. Marital status showed a similar pattern: it was associated with adherence in the bivariate analysis ( $p<0.001$ ), with the highest proportion of adherence observed among married respondents (50.7%), but lost independent significance in the final multivariable model ( $p=0.1194$  during the elimination stage). This finding suggests that the influence of spousal support as an informal caregiving resource may be mediated by other factors, such as healthcare access and utilization.

Overall, the patterns observed across these three predisposing factors suggest that individual demographic characteristics may function more as contextual factors influencing access than as strong direct determinants of routine follow-up adherence. From a healthcare management perspective, these findings indicate that strategies to improve routine follow-up among stroke patients do not necessarily need to be differentiated according to sex or marital status. However, they should address the specific needs of older adults, for example through home-visit programs or transportation services facilitated by community health workers, while also involving spouses and family members in routine follow-up education, particularly for patients without a spouse.

### 3.2.2. Individual Enabling Factors: Educational Attainment and Employment Status

Educational attainment was the most consistent and strongest factor associated with routine follow-up adherence, both in the bivariate analysis (OR for higher education=2.89) and in the multivariable analysis (AOR=2.33; 95% CI 1.91–2.84;  $p<0.001$ ), making it the most dominant factor identified in this study. This finding is consistent with various studies of medication adherence among patients with non-communicable diseases in Indonesia, which have consistently demonstrated associations between education, health literacy, and adherence to follow-up care, as shown in a study of medication adherence within the chronic disease referral program (Nasution et al., 2022). From a health behavior perspective, educational attainment is closely related to health literacy – the ability to understand health information, assess the risk of recurrence, and make informed decisions regarding continued care – as emphasized by the Health Belief Model, which posits that perceived susceptibility and perceived severity of disease recurrence are strongly influenced by an individual's cognitive ability to understand health information (Alyafei & Easton-Carr, 2025).

Employment status was also significantly associated with adherence in the bivariate analysis (OR=1.17;  $p=0.003$ ), but lost independent significance during the initial stage of backward elimination ( $p=0.82$ ). This loss of significance may largely reflect overlap between

employment status and educational attainment, given that these variables are conceptually and empirically correlated as indicators of socioeconomic status. In other words, the effect of employment status on follow-up adherence may operate through educational attainment rather than independently. The managerial implications of these findings include the need for tailored health education strategies for patients with lower educational attainment, such as the use of visual materials, simpler language, or community health worker-based approaches, rather than generic text-based education commonly delivered in primary healthcare facilities. Interventions should therefore focus on improving health literacy rather than merely considering patients' employment status.

### 3.2.3. Contextual Enabling Factors: Area Classification

Residence in an urban area was significantly associated with a higher likelihood of routine follow-up adherence, both in the bivariate analysis (OR=1.55; 95% CI 1.39–1.73) and in the multivariable analysis (AOR=1.21; 95% CI 1.07–1.38;  $p=0.0025$ ). This finding is consistent with a study of regional disparities in hospital utilization in Indonesia based on the 2018 Basic Health Research (Riskesdas), which reported lower utilization of secondary healthcare services among rural populations (Laksono et al., 2023). It is also consistent with findings from the ENHANCE survey showing that rural residents had lower odds of accessing outpatient services at public hospitals (Cheng et al., 2025). These disparities are closely related to the concentration of hospital facilities and specialist healthcare personnel in urban areas, as documented in a study examining the availability of essential medicines in primary healthcare centers across Indonesia (Fanda et al., 2024). From a regional health workforce management perspective, these findings underscore the urgency of improving the equitable distribution of neurologists and stroke-related diagnostic support facilities in rural areas, including through telemedicine and periodic specialist outreach services to reduce geographical barriers to routine follow-up care.

### 3.2.4. Healthcare Facility Utilization and Access Factors

Utilization of hospitals as the household's primary healthcare facility was associated with substantially higher odds of routine follow-up adherence compared with the use of community health centers (Puskesmas), both in the bivariate analysis (OR = 2.49; 95% CI: 2.15–2.88) and the multivariable analysis (AOR = 2.06; 95% CI: 1.76–2.39;  $p < 0.001$ ), making it the second strongest factor associated with adherence after educational attainment. In contrast, respondents from households that did not routinely utilize any healthcare facility had markedly lower odds of attending routine follow-up visits (crude OR = 0.41), whereas utilization of private clinics or independent practices was not significantly different from Puskesmas in the adjusted model (AOR = 0.94;  $p = 0.394$ ). This pattern may be interpreted from the perspective of continuity of specialized care, as stroke survivors commonly require ongoing monitoring by healthcare professionals with expertise in neurovascular conditions, services that are structurally more available in hospitals than in primary healthcare facilities. Nevertheless, this finding also highlights an important managerial challenge within Indonesia's tiered National Health Insurance (Jaminan Kesehatan Nasional [JKN]) referral system. Patients with chronic non-communicable diseases, who are ideally expected to receive continuous long-term management at primary healthcare facilities, demonstrated lower routine follow-up adherence than those whose households primarily utilized hospitals. This observation is consistent with previous evidence suggesting that limited diagnostic capacity,

medication availability, and healthcare workforce capability at primary care facilities weaken the gatekeeping function of primary healthcare, contributing to high referral rates and suboptimal long-term management of chronic diseases at the primary care level (Arlı et al., 2023; Ramadhani, 2020). From a healthcare management perspective, strengthening the capacity of primary healthcare facilities through the Chronic Disease Management Program (Prolanis) should therefore remain a strategic priority to reduce excessive dependence on referral hospitals for routine follow-up care and to improve the overall efficiency of the JKN healthcare delivery system, particularly in the context of the increasing burden on referral hospitals (Febriawati et al., 2023).

Consistent with this pattern, the availability of a hospital in a neighboring district or municipality, rather than within the respondent's own district or municipality, was associated with slightly higher odds of routine follow-up adherence (AOR = 1.29; 95% CI: 1.05–1.58;  $p = 0.017$ ). Although this finding appears counterintuitive, it represents an important phenomenon warranting further consideration. One plausible explanation is the variation in neurological service capacity and perceived quality of care across district hospitals, whereby some stroke patients may be willing to travel longer distances to obtain services perceived as more comprehensive or reliable. This may reflect a healthcare-seeking pattern commonly described as bypassing, in which patients intentionally bypass nearby primary or local healthcare facilities in favor of facilities with stronger reputations or greater perceived service quality, a phenomenon that has been documented in several low- and middle-income country settings, including studies examining disparities in healthcare utilization in Indonesia (Cheng et al., 2025). From a health service management perspective, this finding underscores the importance of standardizing the quality and capacity of neurological and stroke services across district and municipal hospitals. It also highlights the need for systematic evaluation of stroke service quality in hospitals located within patients' own districts, particularly where local facilities appear to be underutilized despite their geographical accessibility.

### 3.2.5. Service Quality and Service-Expectation Congruence

The availability of disability-friendly services at hospitals was associated with routine follow-up adherence in the bivariate analysis (OR = 1.38; 95% CI: 0.92–2.07;  $p = 0.117$ ), although this association did not remain an independent determinant in the final multivariable model. Given the substantial proportion of stroke survivors who experience post-stroke physical disabilities, this finding remains policy-relevant despite the absence of an independent statistical association. This is consistent with evidence indicating that actual healthcare utilization among people with disabilities in Indonesia remains suboptimal and is strongly influenced by physical accessibility barriers and indirect costs, including transportation expenses (Fanda et al., 2026; Kuper et al., 2024; Azizatunnisa' et al., 2025).

A similar pattern was observed for the other five service-quality dimensions—affordability, facility completeness, staff friendliness, physical comfort, and service timeliness—all of which were significantly associated with routine follow-up adherence in the bivariate analyses ( $p < 0.05$ ), supporting the Donabedian model's proposition that structural and process dimensions of healthcare delivery contribute to sustained healthcare utilization (Tossaint-Schoenmakers et al., 2021; Endeshaw, 2021). However, none remained independently significant after adjustment for the primary type of healthcare facility utilized and residential area. This pattern suggests that perceived service quality is strongly correlated with, and may be partly mediated by, the type of healthcare facility utilized by the household.

Hospitals are generally perceived as having more comprehensive facilities, faster services, and greater staff competence than primary healthcare facilities; consequently, the independent effects of these quality dimensions may have been attenuated after adjustment for facility type. This pattern was not observed for perceived affordability (low-cost/free services), which was not significantly associated with routine follow-up adherence even at the bivariate level (OR = 1.08;  $p = 0.329$ ). This finding may partly reflect the broad coverage of Indonesia's National Health Insurance (Jaminan Kesehatan Nasional [JKN]), which has reached the majority of the population and provides relatively standardized financial protection for services delivered by healthcare facilities contracted with BPJS Kesehatan (Pratiwi et al., 2021). Consequently, direct financial barriers may be less influential than geographic and structural barriers in determining routine follow-up among stroke survivors in this study.

In contrast to the other five service-quality dimensions, congruence between services and patient expectations was the only quality dimension that remained independently associated with routine follow-up adherence in the final model (AOR = 1.30; 95% CI: 1.11–1.52;  $p = 0.0012$ ). This finding suggests that perceived alignment between healthcare services and patient expectations represents an important dimension of service quality that is not fully explained by the type of healthcare facility utilized. Within the Donabedian framework, this construct may reflect an outcome-oriented dimension of care while also capturing the gap between patients' expectations and their actual healthcare experience, as conceptualized in patient satisfaction theory. From a healthcare quality management perspective, the finding indicates that healthcare facilities should not focus exclusively on improving physical infrastructure and service capacity but should also ensure that care processes are responsive to patients' individual expectations, including through clear communication regarding treatment plans and follow-up arrangements.

Taken together, these findings highlight the importance of incorporating patient-centered quality improvement into stroke care management. Referral hospitals should prioritize disability-friendly infrastructure and mobility assistance as part of strategies to retain patients in long-term care, particularly given the substantial functional limitations experienced by many stroke survivors.

### **3.2.6. Integrated Synthesis and Implications for Health Administration and Healthcare Service Management**

Overall, the findings indicate that routine follow-up adherence among stroke patients in Indonesia is shaped by an interaction between individual predisposing factors, particularly educational attainment, and structural enabling factors at the healthcare-system level, including the type of healthcare facility utilized, hospital availability, and residential area. In contrast, most perceived service-quality dimensions appeared to be mediated by the type of healthcare facility utilized. This pattern is consistent with Andersen's behavioral model of healthcare utilization, which conceptualizes sustained healthcare utilization as the result of complex interactions between individual characteristics and healthcare-system factors (Xin & Ren, 2023; Mareike et al., 2021; Krzyż et al., 2023). Theoretically, these findings support the application of Andersen's model as an integrated framework that incorporates both individual- and system-level determinants when examining adherence to chronic disease follow-up after stroke, particularly in developing-country settings with tiered referral systems such as Indonesia.

The managerial implications of these findings point to the need for a multilevel strategy. At the individual level, interventions should include health education tailored to patients' health literacy and greater involvement of family members as caregivers. At the health-system level, priorities should include strengthening the capacity of primary healthcare facilities to manage chronic conditions, improving the equitable distribution of referral hospitals and neurologists across regions, standardizing neurological service quality across hospitals, and strengthening patient-centered communication that is responsive to patients' expectations. From a policy perspective, the Ministry of Health and local health authorities should prioritize equitable access to stroke referral services in rural areas, including through telemedicine and specialist outreach programs. Puskesmas managers should strengthen Prolanis for patients with neurovascular non-communicable diseases, while referral hospitals should standardize neurological services and prioritize disability-friendly infrastructure. Future research should employ longitudinal designs incorporating clinical data, individual JKN enrollment status, and post-stroke quality-of-life indicators to strengthen causal evidence regarding determinants of routine follow-up adherence among stroke patients in Indonesia.

### 3.3. Study Limitations

Several limitations should be considered when interpreting the findings of this study. First, the cross-sectional design precludes causal inference between the independent variables and routine follow-up adherence; therefore, the observed relationships should be interpreted as associations rather than causal effects. Second, the service-quality variables represent household-level assessments of the healthcare facility most frequently utilized rather than patient-specific assessments of stroke care. This may have introduced measurement bias at the individual patient level. Third, stroke diagnosis was self-reported and was not verified against medical records, creating the possibility of recall bias and misclassification of stroke status or stroke type. Fourth, the study did not include clinical variables such as stroke severity, stroke type (ischemic or hemorrhagic), comorbidities, time since diagnosis, or individual JKN enrollment status, which were not directly available in the analyzed modules. Consequently, the observed associations may be affected by unmeasured confounding. Fifth, the seven service-quality dimensions may exhibit multicollinearity because they were derived from a common assessment instrument, potentially attenuating their independent effects in the multivariable model.

Sixth, the primary analysis (Sections 3.2–3.3) did not account for the SKI 2023 survey weights ( $w_{final}$ ) or the complex sampling design, including strata and primary sampling units (PSUs). Consequently, the reported confidence intervals may be underestimated, and generalization of the findings to the national population should therefore be undertaken with caution. The survey-weighted logistic regression sensitivity analysis (Section 3.4) showed that the direction and magnitude of associations for educational attainment, hospital utilization, and urban residence were relatively consistent with the primary unweighted model. However, two estimates changed substantively: respondents aged  $\geq 70$  years showed significantly lower odds of routine follow-up adherence in the weighted model (weighted AOR = 0.58; 95% CI: 0.36–0.94;  $p = 0.026$ ) compared with the non-significant association in the unweighted model (AOR = 0.97;  $p = 0.808$ ), while the availability of a hospital in a neighboring district or municipality was no longer independently significant (weighted AOR = 0.91; 95% CI: 0.65–1.26;  $p = 0.568$ ) compared with AOR = 1.29 ( $p = 0.017$ ) in the primary model. These

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differences indicate that accounting for the complex survey design can affect both the precision of estimates and the conclusions for certain variables. Future analyses using SKI 2023 data should therefore consider survey-weighted analysis as the primary analytical approach rather than solely as a sensitivity analysis.

Seventh, the use of complete-case analysis, which excluded 706 of 5,621 cases (12.6%), raises important concerns regarding potential missing-data bias. The excluded cases had substantially lower routine follow-up adherence (31.6%) than the 4,915 cases retained in the final model (51.2%), and more than half of the excluded cases (357 cases) came from households reporting no routinely utilized healthcare facility. This pattern suggests that the missingness is unlikely to be missing completely at random (MCAR) and may instead be associated with the outcome or other unobserved characteristics. Accordingly, the 51.2% adherence proportion among the complete cases may overestimate the corresponding proportion in the overall eligible population (48.7%). Future studies should consider multiple imputation or pattern-mixture approaches to assess and potentially mitigate the impact of missing data.

Eighth, all 357 respondents from households reporting no routinely utilized healthcare facility had structurally missing data for the seven service-quality variables because these questions were skipped for households that did not identify a routinely utilized healthcare facility. Consequently, the “no facility” category, despite having the lowest crude odds of routine follow-up adherence in the bivariate analysis ( $OR = 0.41$ ), was automatically excluded from the multivariable model. A similar pattern resulted in the exclusion of the “no hospital” category for hospital availability from the final model. Therefore, the multivariable analysis could not establish whether the absence of a routinely utilized healthcare facility remained an independent determinant of non-adherence after adjustment for other factors, even though this group demonstrated the highest risk of non-adherence in the bivariate analysis. Future research should integrate clinical information, individual JKN enrollment status, longitudinal follow-up, and appropriate missing-data strategies that distinguish between missing at random and structurally missing data resulting from questionnaire skip patterns. Such approaches would provide a more comprehensive understanding of the determinants of routine follow-up adherence among stroke patients in Indonesia, particularly among vulnerable households that are systematically excluded from multivariable analyses.

## Conclusions

This study concludes that routine follow-up adherence among stroke patients at healthcare facilities in Indonesia is independently associated with six factors: age group, educational attainment, residential area, the type of healthcare facility most frequently utilized by the household, hospital availability within the district/municipality, and the extent to which healthcare services meet patients' expectations. Higher educational attainment was the strongest determinant, followed by the utilization of hospitals as the primary healthcare facility.

These findings suggest that routine follow-up adherence among stroke patients is more strongly influenced by structural factors related to access to and utilization of referral healthcare services than by sociodemographic characteristics alone. Educational attainment was the only individual predisposing factor that remained independently associated with routine follow-up adherence after adjustment for other variables.

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The key implication is the need for a multilevel intervention strategy, combining efforts to strengthen health literacy at the individual level with improvements in the equitable access to and quality of stroke referral services at the health-system level. These two complementary pillars are essential for strengthening the continuity of secondary stroke prevention and long-term care in Indonesia.

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### Conflicts of Interest

The authors declare no conflict of interest.

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