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# Survival Analysis of Stroke Incidence in National Health Insurance Participants from 2015 – 2020

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## Abstract

This study aims to analyze the survival of stroke patients enrolled in the National Health Insurance (*Jaminan Kesehatan Nasional*, JKN) program and factors affecting it during the 2015–2020 period. Survival analysis was utilized using the Kaplan-Meier estimator and the Cox Proportional Hazards model. The dataset consisted of 12,773 stroke patients sampled from BPJS Kesehatan administrative records. The results indicate that since being registered as BPJS Kesehatan participants or from the baseline year 2015, stroke patients had an average survival time of 2,264 days, with a 95% confidence interval between 2,240 and 2,287 days. The Cox model revealed that patients aged 18–35, 36–50, 51–65, and >65 had Hazard Ratios (HR) of 1.30, 1.69, 2.47, and 3.52, respectively. Female patients exhibited a lower risk of death (HR = 0.81) than males. Employment segment effects were modest, and regional disparities were observed, with the Eastern region showing a higher risk (HR = 1.29). Comorbidities further increased hazards, with hypertension (HR = 1.70) and diabetes (HR = 2.17) significantly raising mortality risk. As one of the first large-scale survival analyses using JKN national data, this study offers novel evidence on key determinants of stroke outcomes in Indonesia. Its findings highlight critical risk factors and support more targeted, data-driven strategies for stroke prevention under universal health coverage.

**Keywords:** Cox Proportional Hazard; Kaplan-Meier; National Health Insurance Agency; Stroke; Survival Analysis.

## Abstrak

*Penelitian ini bertujuan untuk menganalisis survival pasien stroke yang terdaftar dalam program Jaminan Kesehatan Nasional (JKN) dan faktor-faktor yang memengaruhinya selama periode 2015–2020. Metode yang digunakan adalah analisis survival dengan pendekatan Kaplan-Meier dan model Cox Proportional Hazards. Data yang dianalisis diambil dari sampel BPJS Kesehatan peserta JKN selama 2015–2020, yang berjumlah 12.773 pasien. Hasil penelitian menunjukkan bahwa sejak terdaftar sebagai peserta BPJS Kesehatan atau sejak tahun dasar 2015, pasien stroke memiliki waktu survival rata-rata 2.264 hari, dengan interval kepercayaan 95% antara 2.240 dan 2.287 hari. Model Cox mengungkapkan pasien berusia 18–35, 36–50, 51–65, dan >65 memiliki* HR *masing-masing sebesar 1,30, 1,69, 2,47, dan 3,52. Perempuan memiliki risiko lebih rendah (*HR *= 0,81) dibandingkan laki-laki. Efek pada segmen pekerjaan relatif kecil, dan disparitas regional teramati, dengan wilayah Timur menunjukkan risiko yang lebih tinggi (*HR *= 1,29). Komorbiditas semakin meningkatkan risiko, dengan hipertensi (*HR *= 1,70) dan diabetes (*HR *= 2,17) secara signifikan meningkatkan risiko mortalitas. Sebagai salah satu analisis survival skala besar pertama yang menggunakan data nasional JKN, studi ini menawarkan bukti baru tentang determinan utama luaran stroke di Indonesia. Temuannya menyoroti faktor risiko kritis dan mendukung strategi pencegahan stroke yang lebih terarah dan berbasis data dalam kerangka jaminan kesehatan semesta.*

***Kata Kunci:*** Cox Proportional Hazard; Kaplan-Meier; *Jaminan Kesehatan Nasional*; Stroke; Analisis survival.

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## 1. INTRODUCTION

Stroke is defined as a clinical syndrome involving a sudden onset of focal neurological impairment caused by vascular injury to the central nervous system, most commonly due to cerebral infarction or hemorrhage [1]. Stroke is a neurological disorder that occurs when blood flow to the brain is disrupted. If the brain's blood supply is impeded, brain tissue will be deprived of oxygen and nutrients, leading to damage. There are two primary types of strokes: ischemic stroke, caused by a blockage in the blood vessels, and hemorrhagic stroke, resulting from a ruptured blood vessel within the brain.

Stroke continues to be one of the leading causes of death globally. According to the Global Burden of Disease (GBD) 2020 report by the World Stroke Organization, approximately 7,253,000 people died due to stroke, with the highest mortality rate found in individuals under the age of 70, accounting for nearly 33% of total stroke-related deaths [2]. This indicates that stroke not only affects the elderly but also significantly impacts the productive-age population. In Indonesia, the Institute for Health Metrics and Evaluation (IHME) in 2019 reported that stroke accounted for 19.42% of all deaths [3]. According to Indonesia's Vital Statistics Report 2019–2023, published by Statistics Indonesia (BPS), the number of administratively recorded deaths in 2023 reached 935,842 individuals. The 2018 Basic Health Research data show a stroke prevalence of 10.9 per 1,000 people, with the highest incidence recorded in the Special Region of Yogyakarta and East Kalimantan. It shows that stroke is not only a global health issue but also a significant contributor to morbidity and mortality at the national level, especially in Indonesia [4].

Several factors increase the risk of stroke at a younger age, including unhealthy lifestyle habits such as smoking, excessive alcohol consumption, depression, cognitive impairment, and declining human productivity. Other contributing risk factors include hypertension, hyperlipidemia, obesity, and diabetes mellitus [5]. The high mortality rate due to stroke has prompted the Indonesian government to establish various control measures, including the National Health Insurance (JKN) Program under Law No. 40 of 2004 on the National Social Security System (SJSN). This program guarantees comprehensive health protection for all citizens. Stroke, classified under non-communicable diseases (NCDs), is a priority in the national disease control strategy, as outlined in the Ministry of Health's Strategic Plan 2020–2024 (Regulation No. 21 of 2020). Since 2014, the government has integrated cardiovascular diseases into the JKN coverage. This program provides basic health protection for all residents, including foreign nationals residing in Indonesia for more than six months. As of December 31, 2024, the number of BPJS Kesehatan participants reached 278,120,393 across various membership categories [6][7].

The occurrence and outcomes of stroke cannot be attributed to a single cause but are shaped by the complex interaction of multiple risk factors (covariates), both modifiable and non-modifiable. Evidence indicates that hypertension increases the risk of stroke by 2.9 times, while age, diabetes status, and stroke type further dominate as determinants of patient survival [8][9]. To capture these multifactorial influences, this study employs the Kaplan-Meier method, which is well-suited for estimating survival probabilities over time. Since nonparametric models are not useful for controlling the covariates, the Cox PH model is a multiple regression method. It is used to evaluate the effect of multiple covariates on survival [10]. The Cox Proportional Hazards model also allows simultaneous assessment of multiple covariates affecting patient outcomes. Using data from 432 stroke patients in a particular hospital in Ethiopia, [11] using the Cox model, reported that more than half (51.6%) died, with a median survival time of only 15 days. Advanced age, atrial fibrillation, alcohol use, hemorrhagic stroke type, hypertension, and diabetes were significant predictors of shorter survival. In Indonesia,

[8] have demonstrated the effectiveness of the Cox Proportional Hazard methods in the context of stroke. However, this study offers a novel contribution by utilizing a large-scale national dataset from BPJS Kesehatan period 2015 – 2020 with 12,773 stroke patients, while also incorporating underexplored variables such as JKN participant segmentation and regional residence.

This study employs Kaplan-Meier and Cox Proportional Hazards methods to estimate survival time distributions and to identify key factors influencing mortality risk. The results underscore the significant roles of age, gender, comorbidities, and participant segmentation in determining survival outcomes. These findings not only contribute to academic knowledge but also offer strategic insights for evaluating and improving stroke control policies in Indonesia. Leveraging a large-scale dataset and an actuarial perspective, this research is positioned to garner interdisciplinary interest from policymakers, public health experts, and actuarial professionals in the health insurance sector.

## 2. METHODS

### 2.1. Data Source and Variables

This study employed secondary data obtained from BPJS Kesehatan, representing participants of the National Health Insurance (JKN) program during the 2015–2020 period. The dataset comprised approximately 1,009,800,000 participants, from which 12,773 individuals were identified as stroke patients based on ICD-10 codes I60–I69. The observation period began on January 1, 2015, or the date of JKN enrolment (whichever occurred later). It continued until the event of death due to stroke, censoring, or the study endpoint on December 31, 2020. The sample is based on family-level data, where all registered members within a household were automatically included as part of the research sample. The sample selection was conducted independently by BPJS Kesehatan, based on the year of participation in the JKN program, using a stratified random sampling method. Stratification was performed based on a combination of family classification and the type of primary healthcare facility accessed by participants. Although the sample data were initially recorded starting on January 1, 2015, adjustments in reporting throughout 2015 meant that valid and consistent data only became available from January 1, 2016. Therefore, the start point for this study is January 1, 2016, and the endpoint is December 31, 2020.

The response (dependent) variable $T$ is survival time, defined as the number of days from the baseline to the occurrence of death due to stroke. Participants who remained alive, died of other causes, or exited JKN membership during the observation period were treated as censored. The time points represent the beginning and end of the observation period used to calculate the survival time for everyone:

$$S_x(t) = 1 - F_x(t) = Pr\ Pr\ [T_x > t], \tag{1}$$

which is a nonincreasing function and defined on [0, 1] as $t \in (0,\infty)$. The covariates ($X_{ki}$) consist of:

1) Age Group ($X_{1i}$): categorized into 0 – 17, 18 – 35, 36 – 50, 51 – 65, and > 65 years,
2) Gender ($X_{2i}$): male or female,
3) JKN Membership Segment ($X_{3i}$): (*Penerima Bantuan Iuran APBN*/Contribution Assistance Recipients – State Budget), (*Penerima Bantuan Iuran APBD*/Contribution Assistance Recipients – Regional Budget), (*Pekerja Penerima Upah*/Wage-Recipient Workers), (*Pekerja Bukan Penerima Upah*/Non-Wage Workers), and (*Bukan Pekerja*/Non-Workers),

4) Regional Domicile ($X_{4i}$): Java-Bali; Sumatra; Kalimantan; Sulawesi; and Eastern Indonesia.
5) Hypertension Comorbidity Status ($X_{5i}$)
6) Diabetes Comorbidity Status ($X_{6i}$).

### 2.2. Data Validity and Censoring

The BPJS Kesehatan dataset is considered nationally representative and reliable, validated through standardized claim verification protocols employing ICD-10 and INA-CBGs coding. Data preprocessing was conducted to ensure accuracy and consistency, including the following steps: 1) verification of completeness and consistency of diagnosis and mortality records. 2) removal of duplicate participant records, 3) handling of missing data: listwise deletion was applied when critical variables such as diagnosis codes or dates of death were absent, 4) coding of survival status as event (death due to stroke) or censored.

Participants were censored if they remained alive at the end of the observation period (December 31, 2020), if they exited JKN membership before the endpoint, or if they died of causes unrelated to stroke. Participants who died prior to January 1, 2015, were not included, as left truncation was not applicable to the dataset. This censoring is important to manage in survival analysis because statistical methods such as Kaplan-Meier and the Cox proportional hazards model are designed to account for this incomplete data to produce unbiased and accurate estimates of survival time and the influencing risk factors.

### 2.3. Method of Data Analysis

The analysis method in this study consists of two main stages: descriptive analysis and survival analysis. The purpose of the descriptive analysis was to illustrate the general characteristics of the dataset. In contrast, the survival analysis was employed to assess the survival of stroke patients based on relevant risk factors. The descriptive analysis will describe the data by categories such as gender, age, residence, JKN participant segmentation, and comorbidity history. These results provided a foundational understanding of the profile of JKN participants included in the study and served as a basis for further analysis in the survival phase. Survival analysis is used to evaluate time-to-event data. In this context, it measures the time as the number of days from the baseline to the occurrence of death due to stroke.

This study employs survival analysis using the Kaplan-Meier method and the Cox Proportional Hazard model. The Kaplan-Meier method estimates the survival function of stroke patients based on the timing of death events. This method provides the probability of survival within a specified time interval without taking covariate effects into account. It also illustrates the survival curves for each variable. Meanwhile, the Cox Proportional Hazard model assesses the impact of covariates on the time to death within the study.

The Kaplan-Meier method was applied to estimate survival probabilities of stroke patients across covariate categories. The survival function estimator is expressed as:

$$\prod_{t(j)\leq 1}\left(\frac{n_j-d_j}{n_j}\right), \qquad (2)$$

where $t_j$ is the duration until the time of death of the j-*th* observation subject related to stroke, $d_j$ is the number of observation subjects who died from stroke during the period $t_j$ and $n_j$ is the number of observation subjects at risk just before time $t_1$. The variance of distribution functions is

$$Var\left(\tilde{F}(t)\right) = Var\left(\tilde{S}(t)\right) \approx \tilde{S}(t)^2 \sum_{i:t_i \le t} \frac{d_i}{n_i(n_i - d_i)}. \quad (3)$$

Thus, the standard error of the survival function is therefore:

$$\sqrt{var\left(\tilde{s}(t)\right)}\ . \quad (4)$$

Steps of Kaplan-Meier Estimation are: 1) defining survival time from baseline to event or censoring, 2) code survival status as event = 1 (death due to stroke) or censored = 0, 3) constructing Kaplan-Meier survival curves for each six covariates group, 4) comparing survival distributions across groups using the Log-Rank test with α=0,05, and 5) estimating median survival time and 95% confidence intervals.

The Cox Proportional Hazard Method is used to analyze the influence of covariates on the hazard or risk of a specific event, such as mortality with a final diagnosis of stroke. The model is designed to identify the factors that contribute to either an increase or decrease in risk. This method is applied to assess how covariates affect the hazard or likelihood of particular outcome—specifically, death due to stroke—and to determine which factors significantly influence the elevation or reduction of that risk.

The Cox Proportional Hazards (PH) model was used to estimate the effect of covariates on the hazard of death due to stroke. The model is formulated as:

$$H_i = \exp\left(\beta_1 x_{1i} + \beta_2 x_{2i} + \dots + \beta_k x_{6i}\right) h_o(t), \quad (5)$$

where, $h_o(t)$ is the baseline hazard function, $\beta_1\beta_2 \dots, \beta_6$ are the regression coefficients, and $x_{1i}x_{2i} \dots, x_{6i}$ covariates (age, gender, domicile, membership segment, hypertension status and diabetes status).

The steps of cox proportional hazard analysis consist of

1. Specifying the model specification
   Define the dependent variable as survival time (in days) and the event indicator ($1 = death\ due\ to\ stroke, 0 = censored$). Covariates included age group, gender, JKN membership category, domicile, hypertension status, and diabetes status.
2. Estimating regression coefficients
   Apply partial likelihood estimation to calculate regression coefficients ($\beta$) for each covariate.
3. Assessment of statistical significance
   Conduct the Wald test for individual $\beta$ coefficients and the Likelihood Ratio test for the overall model. A significance level of α = 0.05 was used.
4. Hazard Ratio computation and interpretation
   Calculate hazard ratios (HR = exp(β)) with 95% confidence intervals. $HR > 1$ indicates a higher risk of mortality (shorter survival) and $HR < 1$ indicates a lower risk of mortality (longer survival).
5. Proportional Hazards assumption testing where we conduct a global Schoenfeld test for overall model validity.
6. Model validation and reporting
   Confirming that the proportional hazards assumption was satisfied. Present adjusted hazard ratios with their confidence intervals and interpret the findings in relation to stroke survival determinants..

## 3. RESULTS

### 3.1. Descriptive Statistics

Tabel 1 presents the descriptive characteristic of stroke patients, categorized by covariates: age, gender, domicile, membership segment, hypertension status and diabetes status. This table summarizes the number of participants, the proportion of censored data and the number of deaths due to stroke for each category.

**Table 1.** Data characteristics

| Description | Number of Observation Participants | % | Censoring Participants | % | Participants with Deceased Status | % |
|---|---|---|---|---|---|---|
| **Hypertension Status** | | | | | | |
| No | 8,996 | 70.4 | 6,772 | 69.5 | 5137 | 64.4 |
| Yes | 3,777 | 29.6 | 2,978 | 30.5 | 2844 | 35.6 |
| Total | 12,773 | 100 | 9,750 | 100 | 7981 | 100 |
| **Diabetes Status** | | | | | | |
| Yes | 10,291 | 80.6 | 1,922 | 80.3 | 5953 | 74.6 |
| No | 2,482 | 19.4 | 7,828 | 19.7 | 2028 | 25.4 |
| Total | 12,773 | 100 | 9,750 | 100 | 7981 | 100 |
| **Age** | | | | | | |
| 0 - 17 Years | 1,875 | 14.7 | 1,705 | 17.5 | 1110 | 14 |
| 18 - 35 Years | 3,157 | 24.7 | 1,758 | 18 | 849 | 11 |
| 36 - 50 Years | 3,794 | 29.7 | 1,465 | 15 | 1697 | 21 |
| 51 - 65 Years | 2,630 | 20.6 | 1,439 | 14.8 | 2361 | 30 |
| > 65 Years | 1,317 | 10.3 | 3,383 | 34.7 | 1964 | 24 |
| Total | 12,773 | 100 | 9,750 | 100 | 7981 | 100 |
| **Gender** | | | | | | |
| Women | 6,446 | 50.5 | 4,947 | 50.7 | 3831 | 48 |
| Male | 6,327 | 49.5 | 4,803 | 49.3 | 4150 | 52 |
| Total | 12,773 | 100 | 9,750 | 100 | 7981 | 100 |
| **Employment Segmentation** | | | | | | |
| PBI APBN | 3,831 | 30 | 1,924 | 19.7 | 2478 | 31 |
| PBPU | 2,582 | 20.2 | 2,960 | 30.4 | 1564 | 20 |
| PPU | 2,532 | 19.8 | 1,924 | 19.7 | 1434 | 18 |
| PBI APBD | 2,527 | 19.8 | 1,900 | 19.5 | 1692 | 21 |
| Bukan Pekerja | 1,301 | 10.2 | 1,042 | 10.7 | 813 | 10 |
| Total | 12,773 | 100 | 9,750 | 100 | 7981 | 100 |
| **Region** | | | | | | |
| Region 1 | 2,619 | 20.5 | 1,988 | 20.4 | 1471 | 18 |
| Region 2 | 2,613 | 20.5 | 1,912 | 19.6 | 1542 | 19 |
| Region 3 | 2,566 | 20.1 | 1,947 | 20 | 1553 | 19 |
| Region 4 | 2,529 | 19.8 | 1,991 | 20.4 | 1625 | 20 |
| Region 5 | 2,446 | 19.2 | 1,912 | 19.6 | 1790 | 22 |
| Total | 12,773 | 100 | 9,750 | 100 | 7981 | 100 |

Based on Table 1, of the 2,773 observed participants, the majority had no history of hypertension, accounting for 70.43%. This pattern is also reflected among participants who died, where 64.36% had no history of hypertension. Regarding diabetes as a comorbid condition, the majority of participants—80.57%—had a history of diabetes. This aligns with the proportion of deceased participants, of whom 74.59% had diabetes as a comorbidity. In terms of age classification, most participants were adults over the age of 35, representing 60.6% of the total sample. This group includes individuals aged 36–

50 years (29.70%), 51–65 years (20.59%), and over 65 years (10.31%). This distribution correlates with the mortality data, where 75% of total deaths occurred in this age group, with the highest death rate among participants aged 51–65 years (30%), followed by those over 65 (24%), and those aged 36–50 (21%).

Among the observed sample, the proportion of female participants was slightly higher at 50.47%, compared to male participants at 49.53%. However, when examining mortality, male participants had a higher death rate at 52%, while females accounted for 48%. In terms of membership segmentation, most participants were from the Government Subsidized Contribution (PBI) group funded by the national budget (APBN), accounting for 29.99%, followed by participants from the Informal Worker (PBPU) segment at 20.21%. In the distribution of deceased participants, the APBN-funded PBI group also showed the highest proportion of deaths at 31%, followed by the regionally funded PBI group (APBD) at 21%.

From a regional perspective, the majority of participants resided in Regional 1, which includes the provinces of Banten, DKI Jakarta, West Java, Central Java, Yogyakarta, and East Java, representing 50% of the total sample. Meanwhile, the highest mortality rate was recorded in Regional 5 at 22%. Based on the research data, out of the 12,773 participants, 4,792 deaths were attributed to stroke. The remaining 7,981 participants—equivalent to 65.02%—either survived through the end of the observation period or died during the period but with a final diagnosis other than stroke. To estimate the average survival time of stroke patients during the observation period, a survival analysis was conducted on the full sample. This estimate provides insight into the general life expectancy of stroke patients based on the observed data. The detailed results are presented in Table 2.

**Table 2**. Mean survival time

| Estimate | Std. Error | 95% Confidence Interval | |
|---|---|---|---|
| | | Lower Limit | Upper Limit |
| 2263.680 | 11.889 | 2240.374 | 2286.986 |

The results of Table 2. indicates that the estimated average survival time for stroke patients in this study is 2,263.680 days. This estimate is considered reliable, as indicated by the relatively small standard error of 11.889. At a 95% confidence level, it can be stated that the true average survival time for the population of stroke patients represented by this sample likely falls within the range of 2,240.374 to 2,286.986 days. Therefore, based on the analyzed data, stroke patients are generally estimated to have a life expectancy of approximately 2,264 days, with a 95% probability that the true average lies between 2,240 and 2,287 days.

Table 3 shows the Variance Inflation Factor (VIF) values for each variable included in the survival analysis. It is shown that the VIF of each covariates values below 5, indicating that there is no significant multicollinearity issue among them. These variables are considered safe to use in survival analysis. To complement the analysis of relationships between covariates, a covariance analysis was conducted and visualized in the form of a heatmap. This visualization provides an overview of the strength and direction of relationships between variables that influence patient survival time. Figure 1 displays the heatmap of the covariant matrix for the variables used in the research. Based on the covariance analysis result in Figure 1, it was found that the distribution of key variables—such as diabetes status, hypertension, and other demographic factors—was quite diverse, indicating heterogeneity within the study population. Furthermore, the results of the covariance analysis revealed relatively low correlations between variables, with covariance values ranging from -0.02 to 0.16. This suggests that there are no strong correlations between variables that could result in high multicollinearity. This supports the assumption that each variable contributes uniquely to the analytical model, such as the Cox proportional hazards model.

**Table 3**. Multicollinearity of Covariates

| Category | VIF |
|---|---|
| Gender | 1.001 |
| Age | 2.022 |
| Employment Segmentation | 1.528 |
| Region | 1.632 |
| Diabetes Status | 1.001 |
| Hypertension Status | 1.001 |

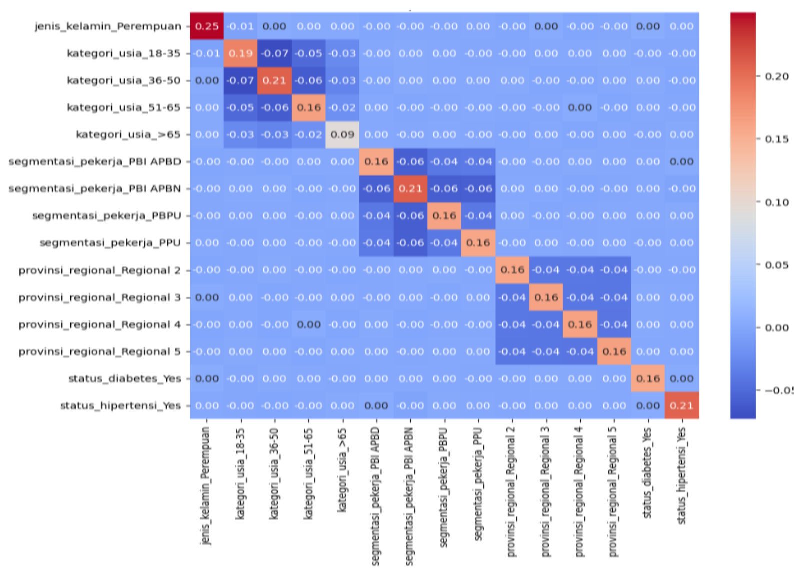



**Figure 1.** Heatmap of covariant matrix

The findings also indicate that certain variables, particularly hypertension and diabetes status, have a significant impact on patient survival time, with hazard ratios reflecting an increased risk of death for patients with those conditions. These results are consistent with previous literature and reinforce the importance of clinical factors in predicting patient prognosis. Overall, the analysis provides a solid foundation to conclude that certain factors have a statistically significant influence on patient survival and can serve as a valuable reference for clinical decision-making and health policy development.

### 3.2. Kaplan Meier Estimates

Figure 2. shows the Kaplan-Meier survival function curve, illustrating the survival time of each JKN participant observed during the study period. The x-axis represents the survival time of JKN participants diagnosed with stroke, while the y-axis indicates the probability of survival of JKN participants who remained alive throughout the observation period. The average survival time of stroke patients in this study since being registered as BPJS Kesehatan participants or from the baseline year 2015 was approximately 2,264 days, indicating a relatively long lifespan when compared to the overall average life expectancy.

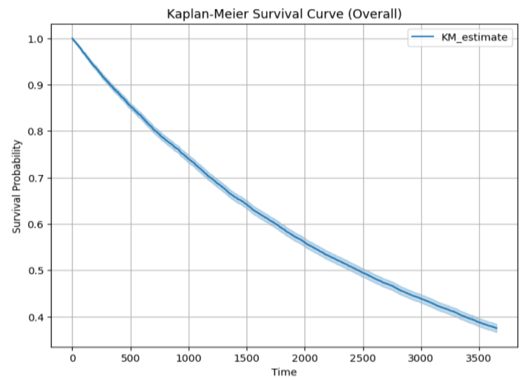



**Figure 2.** Kaplan Meier survival function curve

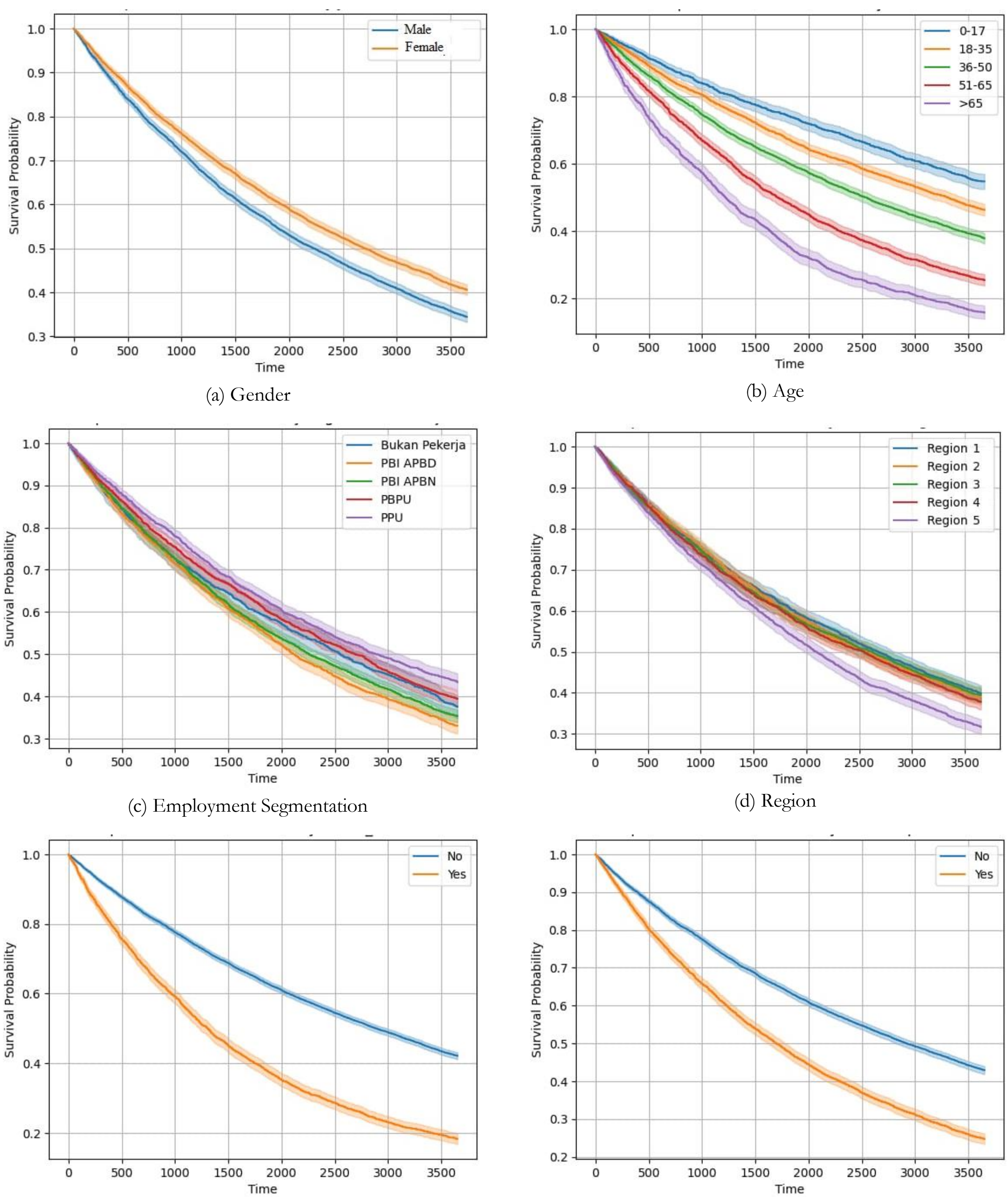
The survival time of individual patients with each level of categorical covariates are shown in Figure 3. In terms of age category, the 18 to 35 age group shows the highest average survival time at 3,298.404 days. This is followed by the 36 to 50 age group with an average survival time of 2,527.358 days, and the 51 to 65 age group with an average of 1,703.861 days. Meanwhile, the age group over 65 years has the lowest average survival time, recorded at 1,217.050 days. Based on gender, women's survival time is better than men's. The average survival time for women is 2,702.752, while for men it is 2,229.180. Based on employment segments, the highest survival time is found in the PPU segment, with an average of 2,884.641 days. This is followed by the PBPU segment, with an average survival time of 2,683.445 days, and the non-Worker segment, with an average of 2,553.696 days. Meanwhile, the segment of PBI APBN recorded an average survival time of 2,260.741 days, while the PBI APBD by regional budgets (APBD) had the lowest survival time, at 2,115.509 days.

Based on the regional covariate, Region 1 has the highest average survival time compared to other regions, at 2,676.711 days. This is followed by Region 3 with an average of 2,612.908 days, Region 2 with 2,560.451 days, and Region 5 with the lowest average survival time of 2,094.554 days. Patients without hypertension comorbidity demonstrate better survival outcomes, with an average survival time of 2,918.353 days, compared to those without hypertension comorbidity, who have an average survival time of 1,692.565 days. For patients without diabetes comorbidity have a higher average survival time, at 2,889.287 days, compared to participants with diabetes comorbidity, who show an average survival time of 1,692.565 days.

If we compare survival distributions across groups using the Log-Rank test with, $\alpha=0.05$, the data indicates significant differences in the survival curves across all analyzed covariate variables—namely gender, participant segment, age group, region of residence, and the presence of comorbidities such as diabetes and hypertension as shown in Table 4.

**Table 4**. Log-Rank test results

| Variabel | Chi-Square | df | Sig. |
|---|---|---|---|
| Gender | 59.1701 | 1 | 0.000 |
| Age | 74.8721 | 4 | 0.000 |
| Employment Segmentation | 1029.1192 | 5 | 0.000 |
| Region | 51.8152 | 4 | 0.000 |
| Diabetes Status | 779.7324 | 1 | 0.000 |
| Hypertension Status | 459.8985 | 1 | 0.000 |




(a) Gender

(b) Age

(c) Employment Segmentation

(d) Region

(e) Diabetes Status

(f) Hypertension Status

**Figure 3.** Kaplan-Meier survivor estimates for covariates of stroke patients

Specifically, variables such as hypertension and diabetes status were found to have a significant impact on patient survival time. This is evidenced by the hazard ratio values, which reflect an increased risk of mortality in patients with these conditions. These findings are consistent with previous literature and reinforce the understanding that clinical factors play a critical role in predicting stroke prognosis [12].

Overall, this analysis provides a strong empirical foundation to conclude that certain factors have a statistically significant influence on patient survival. As such, these findings can serve as a valuable reference for clinical decision-making and the development of more effective, data-driven health policies.

### 3.3. Cox Proportional Hazard Model

The proportionality of the Cox proportional hazard model can be tested using the Cox global model test as shown in Table 5.

**Table 5.** Results of the Cox global model test

| Covariates | B | SE | Z | Sig | EXP(B) |
|---|---|---|---|---|---|
| | | Age | | | |
| 18 - 35 Years | 0.26 | 0.04 | 6.26 | <0.05 | 1.30 |
| 36 - 50 Years | 0.53 | 0.04 | 13.15 | <0.05 | 1.69 |
| 51 - 65 Years | 0.90 | 0.04 | 21.89 | <0.05 | 2.47 |
| > 65 Years | 1.26 | 0.05 | 27.37 | <0.05 | 3.52 |
| Gender | -0.22 | 0.02 | -9.60 | <0.05 | 0.81 |
| | | Employment Segmentation | | | |
| PBI APBD | 0.14 | 0.04 | 3.28 | <0.05 | 1.15 |
| PBI APBN | 0.07 | 0.04 | 1.85 | 0.06 | 1.08 |
| PBPU | -0.08 | 0.04 | -1.86 | 0.06 | 0.92 |
| PPU | -0.16 | 0.04 | -3.68 | <0.005 | 0.85 |
| | | Region | | | |
| Region 2 | 0.03 | 0.04 | 0.95 | 0.34 | 1.04 |
| Region 3 | 0.03 | 0.04 | 0.84 | 0.40 | 1.03 |
| Region 4 | 0.06 | 0.04 | 1.56 | 0.12 | 1.06 |
| Region 5 | 0.25 | 0.04 | 7.21 | <0.005 | 1.29 |
| Hypertension Status | 0.53 | 0.02 | 22.68 | <0.005 | 1.70 |
| Diabetes Status | 0.77 | 0.03 | 29.73 | <0.005 | 2.17 |

To identify which covariates significantly influence the risk of death among stroke patients, a Cox Proportional Hazard model was applied. This model estimates the hazard ratio (HR) for each variable while controlling for the effects of others. Table 5 presents the results of the global model, including regression coefficients, standard errors, Z-values, p-values, and the exponential form of the coefficients [EXP(B)] which represent the hazard ratios. Variables with p-values less than 0.05 are considered statistically significant contributors to the risk of mortality. These results are further interpreted to show the direction and magnitude of each covariate's effect on the hazard of death.

1. Hypertension Status (Coefficient = 0.53)
   $HR = e^{0.53} \approx 1.70.$
   Controlling for other covariates, individuals with hypertension comorbidity have approximately 1.70 times higher risk (hazard) of the event occurring compared to those without hypertension comorbidity.
2. Diabetes Status (Coefficient = 0.77)

HR = $e^{0.77}$ ≈ 2.17.
Controlling for other covariates, individuals with diabetes comorbidity have approximately 2.17 times higher risk of the event occurring compared to those without diabetes comorbidity.

3. Age 18–35 (Coefficient = 0.26)
HR = $e^{0.26}$ ≈ 1.30.
Controlling for other covariates, individuals in the 18–35 age group have approximately 1.30 times higher risk of the event compared to the reference age group.
4. Age 36–50 (Coefficient = 0.53)
HR = $e^{0.53}$ ≈ 1.69.
Controlling for other covariates, individuals in the 36–50 age group have approximately 1.69 times higher risk compared to the reference age group.
5. Age 51–65 (Coefficient = 0.90)
HR = $e^{0.90}$ ≈ 2.47.
Controlling for other covariates, individuals in the 51–65 age group have approximately 2.47 times higher risk compared to the reference age group.
6. Age > 65 (Coefficient = 1.26)
HR = $e^{1.26}$ ≈ 3.52.
Controlling for other covariates, individuals over the age of 65 have approximately 3.52 times higher risk of the event occurring compared to the reference age group. The effect of age increases significantly with advancing age, a finding commonly reported in survival studies.
7. Gender (Coefficient = -0.22)
HR = $e^{-0.22}$ ≈ 0.81.
Controlling for other covariates, females have a 0.81 times lower risk (or 19% lower) compared to males.
8. PBI APBD Segment (Coefficient = 0.14)
HR = $e^{0.14}$ ≈ 1.15.
Controlling for other covariates, individuals in the PBI APBD segment have approximately 1.15 times higher risk compared to the reference segment.
9. PBI APBN Segment (Coefficient = 0.07)
HR = $e^{0.07}$ ≈ 1.08.
Controlling for other covariates, individuals in the PBI APBN segment have approximately 1.08 times higher risk compared to the reference segment. This effect is relatively small.
10. PBPU Segment (Coefficient = -0.08)
HR = $e^{-0.08}$ ≈ 0.92.
Controlling for other covariates, individuals in the PBPU segment have approximately 0.92 times the risk (or 8% lower) compared to the reference segment.
11. PPU Segment (Coefficient = -0.16)
HR = $e^{-0.16}$ ≈ 0.85.
Controlling for other covariates, individuals in the PPU segment have approximately 0.85 times the risk (or 15% lower) compared to the reference segment.
12. Region 5 (Coefficient = 0.25)
HR = $e^{0.25}$ ≈ 1.29.
Controlling for other covariates, individuals residing in Region 5 have approximately 1.29 times higher risk compared to the reference region.

## 4. DISCUSSION

The survival analysis results in this study highlight the impact of multiple demographic and clinical variables on the survival time of stroke patients in Indonesia. The average survival time of approximately 2,264 days indicates a relatively long survival period for stroke patients under JKN coverage, especially when compared to previous hospital-based studies that reported much shorter survival durations. This could be attributed to broader access to healthcare and early detection through the JKN program, underscoring its critical role in improving health outcomes [13].

Age emerged as the most influential predictor of survival, with hazard ratios increasing significantly in older age groups. The risk of mortality was 1.30 times higher in patients aged 18–35 and increased to 3.52 times higher in those aged >65 years, compared to the reference group. This aligns with global findings that associate aging with reduced physiological resilience and greater susceptibility to stroke complications, reinforcing the need for age-specific preventive and therapeutic strategies [14].

Gender was also a statistically significant variable, with female patients demonstrating a lower hazard ratio (HR = 0.81) compared to males. This finding is consistent with literature indicating that hormonal and behavioral factors may offer protective effects in women. However, further investigation is warranted to understand how gender interacts with access to healthcare, treatment adherence, and lifestyle factors under the JKN system. In [15], Gender disparities in healthcare access and treatment outcomes are well-documented, necessitating a deeper understanding of these dynamics within the context of Indonesia's JKN program.

The role of employment segmentation, while relatively modest, still showed measurable differences in survival. Participants from the Wage Recipient Worker (PPU) segment had the highest survival time, possibly reflecting more stable income, better access to employer-provided healthcare benefits, and greater health literacy. In contrast, those in the PBI APBD category exhibited the lowest survival time, highlighting inequalities that warrant targeted interventions in policy implementation. These disparities are evident across various demographic segments, with rural areas and lower-income regions facing the most severe shortages [16].

Regional disparities also surfaced as a significant concern. Patients residing in Region 5 (Eastern Indonesia) exhibited the shortest average survival times, while those in Region 1 (Java-Bali) had the longest. These findings point to geographic inequities in healthcare infrastructure, availability of neurologists and stroke care units, and public health outreach. [17] found that geographic access to neurologists is significantly lower in rural and micropolitan areas compared to metropolitan areas, with rural areas experiencing an 80.49% decrease in access. Reducing these disparities requires improving resource allocation and developing region-specific health strategies [16].

Clinical comorbidities—particularly hypertension and diabetes—were strongly associated with decreased survival, as evidenced by hazard ratios of 1.70 and 2.17, respectively. These findings echo existing studies emphasizing the role of chronic disease management in stroke prognosis. The high prevalence of these conditions among stroke patients indicates an urgent need for integrated care models that address both acute stroke treatment and long-term chronic disease management within the JKN framework.

The Kaplan-Meier survival function and the Cox model consistently confirmed significant variations in survival across covariate categories. These methods allow researchers to assess the impact of various factors on survival outcomes, providing insights into patient prognosis [18]. The log-rank test supported these findings, showing statistically significant differences in survival curves based on gender, age, region, employment segmentation, and comorbidity status. The robustness of these results suggests that survival outcomes among stroke patients are shaped by a complex interplay of demographic [19], regional [20], and clinical factors [20].

This study provides one of the first large-scale empirical assessments of stroke patient survival using a nationally representative dataset from BPJS Kesehatan. The combination of survival analysis and actuarial methods contributes not only to academic knowledge but also offers practical insights for health policy. By identifying key determinants of survival, this research can inform more equitable, evidence-based interventions for stroke prevention and management under Indonesia's universal health coverage system.

Despite the strengths and novelty of this study, several limitations must be acknowledged. First, the global Schoenfeld residuals test indicated that the proportional hazards assumption of the Cox model was violated, suggesting that the estimated hazard ratios may vary over time. This affects the interpretability and robustness of the results derived from the Cox model, particularly for covariates whose effects change throughout the survival period. Second, the model did not account for time-dependent covariates. Variables such as blood pressure and glucose levels, which can fluctuate over time and influence outcomes dynamically, were treated as static. Additionally, censoring was not fully distinguishable; individuals who exited JKN or died from causes unrelated to stroke were all treated as right-censored without further differentiation, which may introduce informative censoring bias.

To address these limitations, future research should aim to integrate administrative claims data with clinical records or hospital registries to enrich the dataset with medical and behavioral variables. Time-varying Cox models or accelerated failure time (AFT) models could be employed to account for non-proportional hazards. Further, subgroup analyses and interaction models can be conducted to identify vulnerable populations with compounded risk. Incorporating longitudinal data will also enable the modeling of dynamic risk factors and treatment effects over time. Additionally, future studies may explore geospatial analysis to better understand regional disparities in healthcare access and its relationship to stroke survival. Finally, predictive models for individualized risk estimation could be developed to support personalized medicine and policy decision-making under Indonesia's national health insurance system.

## 5. CONCLUSION

Based on the survival analysis, it can be concluded that various factors—such as gender, participant segment, age, region of residence, and comorbid status of diabetes and hypertensions — significantly influence the survival time of stroke patients. Female participants, those in the younger age group (18–35 years), and those from the Wage Recipient Worker (PPU) segment exhibited longer survival times. In contrast, male participants aged over 65 and those with a history of diabetes or hypertension had shorter survival times and a higher risk of death. The data also indicate that region of residence affects survival levels, with Region 1 showing better survival outcomes compared to other regions. Overall, the average survival time of stroke patients in this study is approximately 2,264 days, indicating a relatively long-life expectancy compared to the average. Statistical test results show that the differences in survival time across the various variable categories are statistically significant, reinforcing the importance of these factors in stroke patient prognosis.

Based on the Cox Proportional Hazard model analysis, several variables were found to significantly influence the time to death among JKN stroke patients, as indicated by p-values less than

0.05. These variables include age group, gender, membership segmentation, and comorbid status of hypertension and diabetes. This suggests that these factors contribute to either accelerating or shortening the survival duration of stroked patients. Meanwhile, variables such as region of residence did not show a statistically significant effect on the time to death.

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