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ORIGINAL ARTICLE

Changes in nutritional status, risk factors and food intake in stroke subjects: cohort study analysis of non-communicable disease risk factors

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Abstract

Background: Stroke is a major cause of death and disability worldwide, affecting 15 million people annually. In Indonesia, the prevalence is 10.9%. Major risk factors include high blood pressure, obesity, inactivity, poor diet, and smoking.
Objective: This study aims to analyze long-term trends in risk factors, nutritional status, and food intake among stroke patients from 2011-2021, assessing their impact on stroke incidence.
Methods: Data from a longitudinal cohort study of 5,329 subjects, including 215 stroke patients, were analyzed using Microsoft Excel 2019 and SAS software. ANOVA was used to assess annual changes in risk factors, nutritional status, and food intake. Survival analysis was conducted with SAS PROC LIFETEST and PROC LIFEREG.
Results: The cohort was primarily female (62.8%), aged 60 or older (57.2%), senior high school education (25.6%), civil servants (30.7%), and low income (57.2%). Significant changes were noted in BMI (p=0.037), fasting blood glucose (FBG) (p=0.001), HDL (p=0.049), abdominal circumference, smoking habits, physical activity (p<0.001), protein intake (p=0.026), and intake of energy, fat, carbohydrates, and sodium (p<0.001). Factors significantly associated with stroke included age, FBG, postprandial glucose, smoking (p<0.0001), LDL (p=0.0380), HDL (p=0.0126), physical activity (p=0.0455), energy intake (p=0.0002), fat intake (p=0.0007), and sodium intake (p=0.0012).
Conclusions: The study highlights significant changes in nutritional status, glucose levels, HDL cholesterol, physical activity, and smoking habits. These factors, along with age, cholesterol levels, and dietary intake, impact stroke incidence, underscoring the need for comprehensive stroke prevention strategies.

Keywords: stroke prevention, risk factors, longitudinal study, nutritional status, food intake, stroke incidence

Introduction

Stroke is a leading cause of death and disability worldwide with dramatic impacts on millions of lives annually. WHO (2023) reports that stroke affects 15 million people globally annually, resulting in 5 million deaths and 5 million permanent disabilities.[1] In Indonesia, according Riskesdas (2018) 10.9% of the population affected by stroke and 11.4% in West Java, representing about 131,846 individuals stroke.[2]

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Understanding stroke risk factors is crucial for the effective prevention and treatment of stroke. These factors are categorized as modifiable or non-modifiable. Modifiable factors, such as high blood pressure, smoking, poor diet, and physical inactivity, account for 82–90% of stroke cases. Non-modifiable factors include age, sex, and ethnicity.[3,4] Additionally, conditions such as hypertension, diabetes mellitus, high cholesterol, coronary heart disease, atrial fibrillation, and heart valve disease further elevate the stroke risk.[4]

A cohort study is required to gain deeper insights into these factors. In 2011, the Ministry of Health, Republic of Indonesia initiated a cohort study in Bogor City, West Java, involving 5,329 participants. This study examined the impact of behavioral, biomedical, and genomic factors on non-communicable diseases (NCDs), such as stroke. BADAN LITBANGKES (2018) reported a cumulative incidence of metabolic syndrome of 6.8%, diabetes mellitus of 7%, coronary heart disease of 5.3%, stroke of 2.08%, suspected cervical cancer of 2.2%, and breast cancer of 1.9%.[5] Over a 10-year period, this study provides valuable insights into changes in risk factors, nutritional status, and food intake among stroke patients, thereby enhancing our understanding of stroke risk factors specific to Indonesia.

Methods

Study population

This study used secondary data from the FRPTM cohort study conducted by the Research and Development Center for Public Health Efforts of the Indonesian Ministry of Health in Bogor, West Java. The study included adults aged 25 years and older who possessed an Indonesian Identity Card and resided in five selected sub-districts of the Central Bogor District. A total of 5,329 participants were analyzed, of whom 215 experienced a stroke between 2011 and 2021. This study was approved by the Health Research Ethics Committee of the Health Research and Development Agency (numbers: LB.02.01/5.2/KE.143/2014 and LB.02.01/5.2/KE.042/2016). Confidentiality was ensured by anonymizing health data, restricting access to authorized personnel, encrypting digital records, and securely storing physical records

Data collection

Data collection for this study followed the WHO STEP-wise approach, a standardized method for assessing non-communicable disease (NCD) risk factors. This approach involves three key steps. Step 1 involved collecting lifestyle data through questionnaires to assess factors such as physical activity, smoking, and dietary habits (24-hour food recall and a Food Frequency Questionnaire). Step 2 included physical measurements, where anthropometric data, such as weight, height, abdominal circumference, and Body Mass Index (BMI), were recorded. Step 3 involves biochemical measurements, including laboratory tests for biomarkers such as Fasting Blood Glucose (FBG), 2-hour Postprandial Glucose, cholesterol, triglycerides, LDL, and HDL levels. Stroke was defined based on neurological examinations by a specialist and the presence of residual stroke symptoms, supported by patient history and anamnesis. Interviewers were trained staff with at least a diploma in their health. Blood draws are performed by ISO-certified private lab technicians, while anthropometric measurements, blood pressure, and abdominal circumference are assessed by local community health center

Statistical analysis

Data processing and analysis were performed using Microsoft Excel 2019 and SAS software, respectively. Excel was used for the initial data organization and descriptive statistics because of its user-friendly interface and effective tools for basic statistical operations and data visualization. SAS software was selected for its advanced capabilities in managing complex datasets and performing sophisticated statistical analyses. Specifically, SAS PROC LIFETEST was employed for survival analysis to estimate the survival and density functions, providing insights into stroke incidence over time. SAS PROC LIFEREG was used to analyze the factors influencing stroke risk, offering a detailed

examination of survival data and hazard functions. Statistical analyses included univariate analysis to assess the individual risk factor characteristics and their prevalence within the study population. Analysis of Variance (ANOVA) was used to examine changes in risk factors and nutritional status over time, identify significant differences among groups, and help to understand how these factors impact stroke risk. Survival analysis assessed how various factors influence the time until stroke onset, incorporating the survival function to estimate the probability of remaining stroke-free, the probability density function to visualize the likelihood of stroke over time, and the hazard function to estimate the rate at which strokes occur, thus providing insights into periods of increased risk.

Results

Demographic data revealed that the population was predominantly female (62.8%), with males representing 37.2%. Age-wise, the majority were 60 years and older (57.2%), followed by those aged 51-60 years (28.4%), with smaller percentages in the younger age groups. Educationally, most individuals had completed elementary school (31.6%) or junior high school (20.5%), while a small fraction had higher education (3.3%). Domestic workers (27.9%) and civil servants (30.7%) were the most common, while students and private employees were less frequent (0.5% each). Income distribution shows a significant portion of the population with low income (57.2%), contrasted by smaller proportions in the medium (25.1%), high (9.3%), and very high income brackets (8.4%).

Table 1. Individual and socio-economic characteristics of stroke subjects

Variabel	%
Gender	
Male	37.2
Female	62.8
Age	
31-40 years	1.9
41-50 years	12.6
51-60 t years	28.4
≥ 60 years	57.2
Education	
Not school	1.9
Didn't finish elementary school	17.2
Elementary school graduate	31.6
Junior high school graduate	20.5
Senior high school graduate	25.6
University graduate	3.3
Occupation	
Driver	4.7
Domestic worker	27.9
Student	0.5
TNI/POLRI	2.8
Civil Servants	30.7
Self-employed/ Service/Trader	5.1
Private Employee	0.5
Farmer	0.5
Factory worker	2.3
Construction worker	4.2
Retiree	12.1
Other	4.7
Income	
Very high	8.4
High	9.3
Medium	25.1
Low	57.2

Of the 5,329 participants in the FRPTM cohort study, 215 experienced stroke over a 10-year period from 2011 to 2021. **Figure 1** shows the trends in risk factors and nutritional status among stroke subjects. At baseline, the obesity prevalence was 58.1%, decreasing to 20.9% at the 10-year follow-up. Central obesity started at 56.7%, but varied before ending at 21.4%. Low physical activity decreased from 13% to 5.1% and moderate smoking decreased from 10.7% to 4.2%. Diabetes prevalence, as indicated by fasting blood glucose (FBG) and 2-hour postprandial glucose (2h-BG) levels, remained relatively stable, with FBG falling from 13.5% to 6% and 2h-BG from 15.8% to 7%. High triglyceride levels decreased from 27.9% to 12.6%, high total cholesterol levels from 67% to 19.1%, LDL cholesterol levels from 91.2% to 25.6%, and low HDL levels from 55.3% to 14%. These findings reflect improvements in some risk factors, such as reduced obesity and better lipid profiles, but highlight the need for a continued focus on diabetes management and central obesity.

Table 2 presents the significant changes in nutritional status and risk factors for stroke subjects over a 10-year follow-up period, with p-values

indicating statistical significance (p<0.05). Notable changes were observed in body mass index (BMI) (F=2.385, p=0.037), abdominal circumference

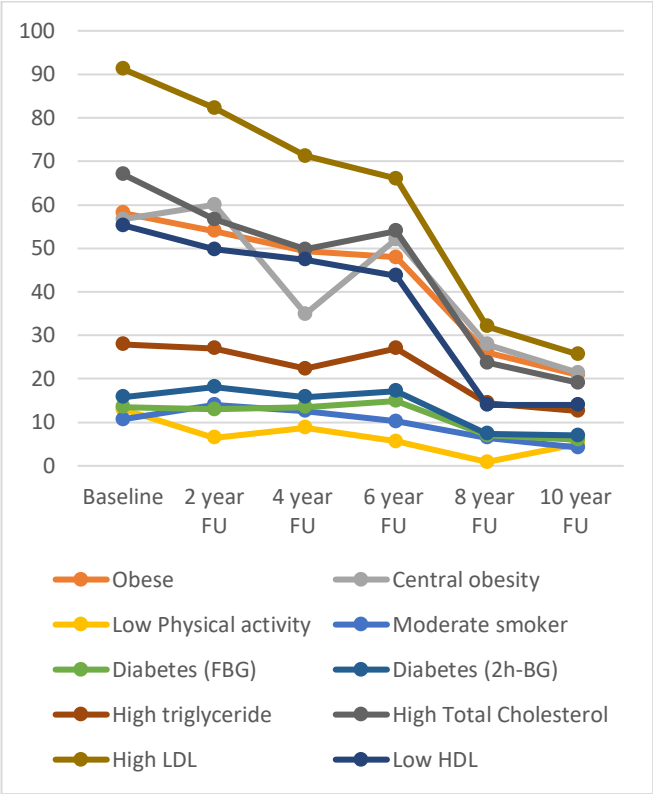

Figure 1. Trends in Risk Factors and Nutritional Status in Stroke Subjects Over a 10-Year Follow-Up Period

(F=13.551, p<0.001), fasting blood glucose (FBG) (F=4.313, p=0.001), HDL cholesterol (F=2.240, p=0.049), smoking habits (F=10.073, p<0.001), and physical activity levels (F=5.207, p<0.001). A significant decrease in BMI and abdominal circumference suggests improvements in weight management, which can reduce the risk of stroke. A decrease in FBG indicates better glucose control, which is crucial for reducing stroke risk. The significant change in HDL levels reflects alterations in lipid profiles, with increased HDL being associated with a reduced risk of stroke owing to its role in clearing LDL cholesterol from the bloodstream. Changes in smoking and physical activity levels also reflect the impact of lifestyle modifications.

Table 3 shows the significant changes in dietary intake over the 10-year follow-up period, with p-values demonstrating statistical significance (p<0.05) for energy intake (F=11.692, p<0.001),

Table 4. Factors affected the incidence of stroke

Table 2. ANOVA results of changes in nutritional status and risk factors of stroke subjects over 10 years *follow up*

Variable	F	Sig
IMT	2.385	0.037
Abdominal Circumference	13.551	0.000
Total cholesterol	1.464	0.199
Fasting Blood Glucose	4.313	0.001
Variable	F	Sig
2-hour Postprandial Glucose	0.909	0.474
Triglycerides	2.065	0.068
LDL	1.259	0.280
HDL	2.240	0.049
Smoking habit	10.073	0.000
Physical activity	5.207	0.000

**significant (p<0.05)*

fat intake (F=70.207, p<0.001), carbohydrate intake (F=49.187, p<0.001), and sodium intake (F=20.509, p<0.001). These results highlight the significant adjustments in dietary patterns, which are essential for evaluating their impact on stroke risk.

Table 3. ANOVA results of changes in nutritional intake of stroke subjects over 10 years

Food Intake	F	Sig
Energy	11.692	0.000
Protein	1.835	0.058
Fat	70.207	0.000
Carbohydrate	49.187	0.000
Sodium	20.509	0.000

Table 4 identifies several factors that significantly affected stroke incidence, with p-values less than 0.05. The significant predictors included age (p<0.0001), fasting blood glucose (FBG) (p<0.0001), 2-hour postprandial glucose (2h-BG) (p<0.0001), LDL cholesterol (p=0.0380), HDL cholesterol (p=0.0126), smoking habits (p<0.0001), physical activity (p=0.0455), energy intake (p=0.0999), and sodium intake (p<0.0001). Additionally, LDL and HDL levels, smoking habits, physical activity, and dietary factors, such as energy, fat, and sodium intake, were assessed. These findings higlight the importance of managing glucose levels, promoting physical activity, and making dietary adjustments in stroke prevention

Variable	Estimate	Standard Error	95% confidence Limits		Chi-Square	Sig
Age	-0.0115	0.0019	-0.0153	-0.0077	35.65	0.0001
IMT	-0.0102	0.0059	-0.0218	0.0014	2.98	0.0842
Abdominal circumference	0.0019	0.0026	-0.0033	0.0070	0.51	0.4768
Total cholesterol	-0.0005	0.0005	-0.0016	0.0005	1.09	0.2975
Fasting Blood Glucose	0.0023	0.0003	0.0017	0.0030	52.59	**0.0001**
2-hour Postprandial Glucose	-0.0008	0.0002	-0.0011	-0.0005	29.69	**0.0001**
Triglycerides	0.0000	0.0002	-0.0004	0.0004	0.00	0.9858
LDL	-0.0012	0.0006	-0.0023	-0.0001	4.30	0.0380
HDL	0.0040	0.0016	0.0009	0.0072	6.23	0.0126
Smoking habit	-0.0003	0.0000	-0.0003	-0.0002	59.55	**0.0001**
Physical activity	0.0000	0.0000	0.0000	0.0000	4.00	**0.0455**
Energy intake	0.0002	0.0000	0.0000	0.0002	6.65	**0.0002**
Protein intake	-0.0008	0.0004	-0.0016	0.0001	2.92	0.0873
Fat Intake	-0.0030	0.0009	-0.0024	0.0011	0.56	**0.0007**
Carbohydrate Intake	-0.0000	0.0001	-0.0002	0.0001	0.12	0.7237
Sodium intake	-0.0001	0.0000	-0.0001	-0.0000	33.08	**0.0012**

Discussion

Individual and socioeconomic subjects

Over a 10-year period, 4.04% of the participants in the cohort study experienced stroke. At baseline, 86 subjects had already suffered a stroke, and this number increased to 215 over the decade. Stroke incidence was higher in women (62.8%) than in men (37.2%). Some studies have reported that women have a higher risk of stroke than men.[6,7] Most stroke patients were elderly (57.2% aged 60 years or older), highlighting age as a risk factor for stroke. The risk of stroke increases with age, and individuals older than 45 years have a higher risk of stroke.[8] In this study, age significantly affected the incidence of stroke (P <0.0001). The risk of stroke increases with age, with the odds doubling after 55 years of age.[9] Aging leads to the deterioration of body organs, including the blood vessels in the brain, which lose elasticity over time. This decline in vascular function is closely linked to the increased risk of stroke as individuals get older. [10,11]

Most stroke patients had an elementary school education level (31.6%) or high school (25.6%). The majority of the participants were employed as civil servants (30.7%) or domestic workers (27.9%). These job types reflect different levels of physical activity and exposure to risk factors such as work-related stress and access to healthcare. Income analysis revealed that most stroke subjects were in the low-income group, with 57.2% having a low income, which may indicate limited access to preventive and adequate medical care.

Nutritional factors

Obesity is defined by a Body Mass Index (BMI) exceeding 25 kg/m², while central obesity is specifically indicated by an abdominal circumference greater than 90 cm in men and over 80 cm in women. Over the course of a 10-year study, data revealed statistically significant changes in both BMI and abdominal circumference, with BMI showing a significant decrease (F=2.385, p=0.037) and abdominal circumference demonstrating even more pronounced changes (F=13.551, p<0.001). Despite these changes, obesity and central obesity persisted as common issues throughout the study period. Obesity worsens ischemic stroke by increasing both systemic and local inflammation.[12] Weight loss and malnutrition are associated with greater neurological impairment and worse clinical outcomes in stroke patients.[13] Poor nutrition during a stroke's acute phase can lead to further malnutrition, complicating recovery and daily functioning.[14]

Lifestyle factors

Physical activity and smoking are significant risk factors for stroke. Physical activity was measured in MET-min/week and smoking was assessed using the Brinkman Index. Over the 10-year follow-up period, there were notable changes in both physical activity ($F = 5.207$, $p<0.001$) and smoking habits ($F = 10.073$, $p<0.001$). These changes suggest an increased awareness of stroke risks and the benefits of lifestyle modifications, consistent with the Health Belief Model (HBM), which posits that individuals alter behaviors based on perceived risks and benefits. Improving patient communication about stroke recurrence risks and implementing a Comprehensive Reminder System based on the HBM could enhance stroke prevention efforts.[15]

This study showed that smoking ($p < 0.0001$) and physical activity ($p = 0.0455$) significantly affected the incidence of stroke. Higher levels of physical activity are associated with a reduced incidence of stroke.[16] Regular exercise is crucial for preventing stroke and aiding recovery by lowering cardiovascular risk, enhancing lung capacity, and improving cognitive function.[17,18] Physical activity is important to prevent secondary complications such as cardiovascular diseases and death.[19] Smoking decreased over the follow-up period, which is important because smoking increases stroke risk through oxidative stress, arterial damage, and plaque buildup. Quitting smoking improves HDL function and lowers cholesterol levels, further reducing stroke risk. [20,21]

Biochemical markers

Blood levels of total cholesterol, triglycerides, LDL, and HDL are useful for diagnosing dyslipidemia. In this study, subjects with stroke had the highest prevalence of elevated cholesterol levels over the 10-year period. High total cholesterol levels are associated with atherosclerosis, which increases stroke risk.[9] Triglycerides stored in fat cells and released for energy are typically normal in stroke patients. However, elevated triglyceride levels can also contribute to arterial plaque formation and inflammation.[22]

Over the 10-year period, HDL levels decreased significantly ($F = 2.240$, $P = 0.049$). The proportion of individuals with low HDL levels decreased from 55.3% to 14.0%, while those with normal HDL levels decreased from 44.7% to 14.0%. HDL plays a crucial role in transporting cholesterol from the tissues back to the liver, preventing atherosclerosis, and protecting against heart diseases.[23] Decreasing HDL levels may suggest a rising public health challenge as low HDL levels are associated with a higher risk of heart disease and stroke. Public health strategies should focus on increasing HDL levels through lifestyle changes such as improved diet, increased physical activity, and smoking cessation.

Both LDL ($p = 0.0380$) and HDL ($p = 0.0126$) levels significantly affected the stroke incidence. LDL is a degradation product of very low-density lipoprotein (VLDL), is associated with higher mortality and decreased blood vessel resilience owing to cell necrosis.[24] Low HDL levels are associated with a high risk of heart disease and stroke.[25] An HDL level of at least 60 mg/dL reduces heart disease risk, whereas levels below 40 mg/dL increase this risk.[23]

Hyperglycemia can damage large blood vessels, increase blood viscosity, raise blood pressure, and elevate stroke risk.[26] During the 10-year follow-up, the highest prevalence of normal fasting blood glucose (FBG) levels was noted. Stroke can result from plaque buildup, which blocks blood vessels in the brain.[27] Stroke patients with high blood sugar levels had a lower risk of FBG levels and showed a significant decrease over the 10 years ($F = 4.313$, $P = 0.001$). Lowering FBG levels positively affects stroke patients, as high FBG levels are independently linked to an increased risk of stroke.[28]

Fasting blood glucose (FBG) and 2-hour postprandial glucose measurements significantly affected the incidence of stroke ($p < 0.0001$). This finding suggests a clear link between diabetes mellitus and stroke. Elevated blood sugar levels can worsen stroke outcome. Diabetes contributes to stroke through several mechanisms, including atherosclerosis, cerebral small-vessel disease (SVD), and impaired blood flow. Individuals with diabetes are at a higher risk for stroke, and high

blood sugar can exacerbate brain damage, increase bleeding risk, and hinder recovery.[11,29]

Dietary intake

Food intake significantly affects the stroke risk. High energy and fat consumption can lead to obesity and dyslipidemia, whereas excessive carbohydrates may cause hyperglycemia. The results showed significant decreases in energy ($F=11.692$, $p<0.001$), fat ($F=70.207$, $p<0.001$), carbohydrate ($F=49.187$, $p<0.001$), and sodium ($F = 20.509$, $p<0.001$) intake. Stroke can cause complications, such as paralysis, neuropsychological issues, and dysphagia, which worsen nutritional deficiencies by limiting movement, disrupting eating habits, and increasing the risk of aspiration.[30]

Nutrient intake is crucial for recovery from stroke. Energy intake ($p = 0.0002$) and fat intake ($p = 0.0007$) significantly affected stroke incidence. Reducing saturated fat may reduce cardiovascular events.[31] Sodium intake also played a significant role ($P =0.0012$). High sodium intake increases blood pressure by causing water retention, increasing systemic resistance, altering endothelial function, and affecting large arteries, all of which contribute to hypertension and stroke.[32] The Indonesian Ministry of Health recommends limiting the sodium intake to 2000 mg per day.[33]

The study's findings are limited by missing data due to incomplete measurements and disruptions from the COVID-19 pandemic in 2020, potentially affecting the accuracy of the results on lifestyle factors and stroke risk. Future research should investigate the long-term effects of physical activity and dietary changes on stroke recovery, and consider socioeconomic factors and healthcare access. Expanding and continuing this cohort study is crucial for a deeper understanding of NCDs in Indonesia, with a focus on integrating comprehensive data and overcoming pandemic-related disruptions to improve the validity and applicability of the findings.

Conclusion

Over a 10-year follow-up period, significant changes were noted in nutritional status, fasting blood glucose (FBG) levels, high-density lipoprotein (HDL) cholesterol, physical activity, and smoking habits among stroke subjects. Key risk factors influencing stroke incidence include advanced age, elevated blood sugar levels, imbalanced cholesterol levels (LDL and HDL), smoking, physical activity, and dietary intake (energy, fat, and sodium). This study highlights how sustained lifestyle modifications such as controlling smoking habits, improving diet, and increasing physical activity are crucial for reducing stroke risk. It provides valuable insights into the long-term impact of these modifications on stroke prevention. These findings underscore the need for proactive management of stroke risk factors and suggest that comprehensive, sustainable prevention strategies are essential. Future research should explore the effectiveness of specific interventions across diverse populations to refine stroke prevention approaches and address the risk factors that evolve with age and lifestyle changes.

Conflict of interest

The authors declare that no conflict of interest with another person or institution

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