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National Trends of Vascular Risk Factor Control Among Stroke Survivors in Korea: From the National Health and Nutrition Examination Survey 2010 to 2021

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ABSTRACT

Background: To prevent stroke recurrence in stroke survivors, effective management of vascular risk factors (VRFs), including hypertension, diabetes, hyperlipidemia, and smoking, is essential. This study aimed to assess the VRF control status and trends among stroke survivors in Korea.

Methods: This cross-sectional study analyzed data from 1,261 stroke survivors aged ≥ 19 years (mean age: 65.2 years; 43.1% female) who were part of the Korea National Health and Nutrition Examination Survey from 2010 to 2021. The control status of VRFs was evaluated using standardized criteria: hypertension (blood pressure < 140/90 mmHg), diabetes (hemoglobin A1c < 7%), hyperlipidemia (low-density lipoprotein cholesterol [LDL-C] < 70 mg/dL), and smoking status. Multivariate logistic regression analysis was conducted to identify factors associated with uncontrolled VRFs.

Results: The rates of age-adjusted hypertension, diabetes, and smoking control remained consistent throughout the observation period. However, overall LDL-C control improved from 30.1% in 2010–2012 to 40.4% in 2019–2021 (P = 0.015), particularly in those aged ≥ 65 years. However, in the 19–49 age group, the control rate decreased from 47.0% to 15.8% (P = 0.048). Smoking rates showed no significant improvement (70.2% in 2019–2021 compared to 69.6% in 2010–2012), particularly among men. Living alone (adjusted odds ratio [aOR], 1.85; 95% confidence interval [CI], 1.03–3.32) was significantly associated with uncontrolled hypertension, whereas living in urban areas was linked to uncontrolled diabetes (aOR, 2.75; 95% CI, 1.06–7.17). Non-health screening was significantly associated with uncontrolled hyperlipidemia (aOR, 2.28; 95% CI, 1.25–4.14), and men were more likely to continue smoking (aOR, 4.47; 95% CI, 3.12–6.72).

Conclusion: These findings highlight the need for targeted health strategies to enhance risk-factor management and reduce stroke recurrence.

Keywords: Stroke; Hypertension; Diabetes; Hyperlipidemia; Smoking; Korea

INTRODUCTION

Stroke is one of the leading causes of mortality and disability worldwide, with its impact particularly severe in aging populations.[1] In South Korea, the incidence of stroke has been increasing, driven by the country's rapidly aging population.[2] As the incidence of stroke increases, the issue of stroke recurrence becomes increasingly critical because recurrent strokes often result in more significant disability and higher mortality rates than first-time strokes.[3] Effective prevention of stroke recurrence hinges on the meticulous management of vascular risk factors (VRFs), including hypertension, diabetes, hyperlipidemia, and smoking.[4] According to a Global Burden of Disease analysis, nearly 90% of the global burden of stroke is attributable to modifiable VRFs.[5] Despite the clear importance of controlling these risk factors, there is a notable scarcity of research focusing on the status and management of these risk factors among stroke survivors in Korea. The Korea National Health and Nutrition Examination Survey (KNHANES) provides a robust and comprehensive database for evaluating health behaviors, disease prevalence, and the management of risk factors in the Korean population.[6] Understanding the current landscape and associated factors of VRF control is essential for designing targeted interventions to reduce the risk of stroke recurrence.

This study examined the status and trends in the management of key VRFs (hypertension, diabetes, hyperlipidemia, and smoking) among individuals with a history of stroke in South Korea using data from the KNHANES. In addition, this study aimed to explore the sociodemographic and clinical factors associated with effective risk factor management.

METHODS

Data and study populations

Data used in this study were obtained from the KNHANES, a cross-sectional and national survey conducted by the Korea Disease Control and Preventive Agency, between 2010 and 2021.[7] The total population surveyed over the 11 years was 95,310. Of these, 1,573 participants aged ≥ 19 years with a diagnosis of stroke were selected. Finally, 1,261 participants with no missing values for the key variables were selected (**Supplementary Fig. 1**).

Variables

Each survey cycle independently collected information from participants. The following VRFs were examined: hypertension, diabetes, hyperlipidemia, and smoking status. Blood pressure (BP) was measured thrice at 30-second intervals after a 5-minute rest period at an ideal ambient temperature of 20–25°C and an ideal noise of ≤ 65 dB in four mobile examination centers according to a defined protocol. The representative BP value was the average of the second and third BP readings.[8] Non-fasting laboratory measurements included hemoglobin A1c and total cholesterol. Participants were classified as having hypertension if their systolic BP was ≥ 140 mmHg, or diastolic BP was ≥ 90 mmHg, or if they answered 'yes' to ever taking antihypertensive medication.[9] Participants were classified as having diabetes if their hemoglobin A1c level was ≥ 6.5% or if they answered 'yes' to ever having diabetes.[10] Hyperlipidemia was defined as total cholesterol ≥ 200 mg/dL or low-density lipoprotein cholesterol (LDL-C) level > 100 mg/dL.[4] Smoking was self-reported and divided into three categories. Participants were defined as current smokers if they answered 'yes' when asked

if they smoked > 100 cigarettes and smoked currently.[11] Past smokers were defined as those who responded that they did not smoke currently but had smoked at least 100 cigarettes in their lifetime. Never-smokers were defined as those who had never smoked or had smoked < 100 cigarettes in their lifetime.[10] General characteristic variables were classified as follows: sex (male or female), age (younger than 50 years, 50–59 years, 60–69 years, 70–79 years, or older than 80 years), marital status (having a spouse or not), number of household members (1, 2, 3, 4, or more), and economic activity (yes or no). Educational level was classified as middle-school graduate or below, high-school graduate, or college graduate or above, and household income was classified as low, low-middle, upper-middle, or upper, based on the corresponding quartile. Residential areas were categorized into urban and rural based on the administrative region of South Korea where the participants lived, and health insurance was classified as National Health Insurance and Medical Aid. Body mass index was classified into < 18.5 kg/m², 18.5 kg/m² to < 23.0 kg/m², 23.0 kg/m² to < 25.0 kg/m², and > 25.0 kg/m². Alcohol consumption was classified as high-risk drinking if men consumed ≥ 7 drinks and women consumed ≥ 5 drinks while drinking more than twice a week. Health checkups were classified as yes or no depending on whether they had been completed in the last two years.

Outcomes

The VRF control rates were defined as follows: 1) hypertension was considered controlled if BP was < 140/90 mmHg.[12] A secondary analysis was performed using a < 130/80 mmHg cutoff, as suggested by the 2017 American College of Cardiology/American Heart Association and 2021 American Heart Association/American Stroke Association recommendations for secondary stroke prevention[4,13]; 2) diabetes was considered controlled if hemoglobin A1c was < 7%[4]; 3) hyperlipidemia was considered controlled if LDL-C was < 70 mg/dL[4]; and 4) smoking was considered controlled if participants did not smoke cigarettes during the survey period. Thus, the participants were categorized as never-smokers or past smokers. The VRF rates were further stratified by age and sex (men vs. women).

Statistical analysis

The KNHANES is designed using stratified cluster sampling rather than simple random sampling. Therefore, to produce unbiased estimates representative of the entire Korean population, sampling weights based on the KNHANES sampling design were applied to all statistical analyses.[14] Baseline characteristics, annual VRF prevalence, and control rates were calculated from the 2010 to 2021 survey cycles. Age- and sex-adjusted means were calculated using the 2010 population as the reference for each outcome. Univariate and multivariate logistic regression analyses were performed to identify the factors associated with uncontrolled hypertension, diabetes, hyperlipidemia, and smoking continuation using the most recent survey results (2019–2021). Characteristics explored in the KNHANES were included as confounding factors. Variables identified as having a $P < 0.100$ in the univariate analysis were included as confounding factors in the multivariate analysis. All statistical analyses were performed using the R statistical software (version 4.1.2; R Foundation for Statistical Computing, Vienna, Austria). Statistical significance was set at a two-sided $P < 0.050$.

Ethics statement

All data analyzed in this study were fully anonymized after informed consent was obtained from all participants. This study was approved by the Institutional Review Board of Seoul National University Hospital (approval number: H-2110-124-1264).

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RESULTS

Baseline characteristics

The prevalence of hypertension, diabetes, hyperlipidemia, obesity, and smoking was 66.4%, 30.2%, 70.1%, 41.6%, and 58%, respectively, in 1,261 stroke survivors (mean age: 65.2 ± 0.8 years, female 43.1%). The place of residence showed a significant difference by year ($P =$ 0.001), with a slightly higher proportion of participants living in urban areas in 2013–2015 (80.2%) than in 2010–2012 (79.4%), whereas this number decreased in 2016–2018 (78.3%) and 2019–2021 (77.5%). The remaining general characteristic variables did not show significant annual differences (**Table 1**).

VRF control

The trends in participants' control of VRFs over time by age are shown in **Table 2**.

For hypertension, control was achieved in approximately 75% of the population using a cutoff of 140/90 mmHg, but in < 50% using a cutoff of 130/80 mmHg. For diabetes, an increase in the control rate was observed from 88.1% in 2019–2021 to 83.2% in 2010–2012; however, the change was insignificant. The proportion of participants who did not smoke cigarettes during the survey was not significant: 87.1% in 2019–2021 and 82.2% in 2010–2012. Among stroke survivors, changes in BP control, glycemic control, and rates of quitting smoking or staying smoke-free from 2010 to 2021 were not significant. However, the change in LDL-C target achievement was significant (P for trend = 0.015). The target goal for LDL-C < 70 mg/ dL was achieved by 30.1% of the participants in 2010–2012, 32.1% in 2013–2015, 40.2% in 2016–2018, and 40.4% in 2019–2021, indicating an increase over time. When examined by age, the results were significant for those aged 19–49 years (15.8% in 2019–2021 vs. 47.0% in 2010–2012, P for trend = 0.048) and ≥ 65 years (47.7% in 2019–2021 vs. 31.7% in 2010–2012, P for trend < 0.001).

VRF control by sex

Age-adjusted control rates for hypertension did not change significantly during the observation period in either men or women. The age-adjusted diabetes control rates significantly improved in men (80.6% in 2010–2012 vs. 87.5% in 2019–2021, P for trend = 0.042) but not in women (86.3% in 2010–2012 vs. 89.1% in 2019–2021, P for trend = 0.837). Controls for hyperlipidemia were significantly improved in both men (32.3% in 2010–2012 vs. 41.4% in 2019–2021, P for trend = 0.046) and women (27.4% in 2010–2012 vs. 38.9% in 2019–2021, P for trend = 0.028), with a cutoff value of LDL-C < 70 mg/dL. However, the percentage of people who did not smoke cigarettes during the survey did not improve during the observation period, particularly among men (69.6% in 2010–2012 vs. 70.2% in 2019– 2021, P for trend = 0.135) (**Supplementary Table 1**). Finally, only 9.4% of the participants achieved the target goal for all four VRFs (10.7% for 19–49 years, 9.5% for 50–64 years, and 9.2% for ≥ 65 years) (**Fig. 1**).

Factors associated with uncontrolled VRFs

Univariate and multivariate analyses based on the 2019–2021 survey were conducted to identify factors associated with uncontrolled VRFs. The results of logistic regression analysis revealed that living alone, without a spouse, was significantly associated with uncontrolled hypertension (adjusted odds ratio [aOR], 1.85; 95% confidence interval [CI], 1.03–3.32; $P =$ 0.038) (**Table 3**). Living in urban areas was associated with uncontrolled diabetes (aOR, 2.75; 95% CI, 1.06–7.17; $P =$ 0.038). Moreover, upper-middle household income was significantly

Table 1. Baseline characteristics of the total participants

| Characteristics	Weighted % (95% CI)				P value
	2010–2012 (n = 229)	2013–2015 (n = 308)	2016–2018 (n = 371)	2019–2021 (n = 353)	
Age, mean ± SD, yr	65.49 ± 0.96	63.92 ± 0.84	65.84 ± 0.70	65.63 ± 0.92	0.333
Sex					0.615
Male	54.1 (46.1–61.9)	59.0 (52.2–65.4)	55.2 (49.6–60.7)	59.3 (53.3–65.0)	
Female	45.9 (38.1–53.9)	41.0 (34.6–47.8)	44.8 (39.3–50.4)	40.7 (35.0–46.7)	
BMI, kg/m²					0.602
< 18.5	1.7 (0.5–5.6)	1.7 (0.7–4.2)	1.7 (0.8–3.6)	2.4 (1.0–5.6)	
18.5–22.9	36.0 (28.8–44.0)	29.8 (24.0–36.4)	28.9 (23.6–34.8)	28.1 (22.8–34.2)	
23.0–24.9	26.0 (21.0–31.6)	21.9 (16.4–28.5)	28.7 (23.4–34.6)	26.7 (21.6–32.5)	
≥ 25.0	36.3 (28.9–44.3)	46.6 (39.9–53.4)	40.8 (35.1–46.7)	42.7 (36.8–48.9)	
Vascular risk factors					0.898
Hypertension	65.0 (57.7–71.7)	65.3 (59.1–71.0)	67.7 (61.6–73.3)	67.5 (61.0–73.3)	
Diabetes mellitus	34.2 (26.9–42.4)	30.0 (24.1–36.7)	31.2 (25.9–37.2)	25.5 (20.6–31.0)	
Dyslipidemia	32.7 (26.0–39.8)	37.5 (31.2–45.1)	39.8 (33.9–46.3)	46.1 (40.6–51.8)	
Marital status					0.268
With spouse	70.2 (61.7–77.5)	72.6 (65.9–78.4)	67.6 (62.0–72.7)	68.3 (62.3–73.8)	
Without spouse	29.8 (22.5–38.3)	27.4 (21.6–34.1)	32.4 (27.3–38.0)	31.7 (26.2–37.7)	
Family member					0.086
1	12.7 (7.8–20.2)	16.5 (12.1–22.1)	19.3 (15.4–24.0)	20.8 (16.6–25.8)	
2	40.1 (33.2–47.3)	42.8 (36.6–49.1)	39.7 (34.1–45.6)	43.3 (37.1–49.7)	
3	26.2 (19.9–33.7)	16.6 (11.7–22.8)	23.9 (18.8–29.9)	18.1 (13.7–23.4)	
≥ 4	21.0 (15.0–28.5)	24.2 (18.4–31.0)	17.1 (12.8–22.4)	17.8 (12.5–24.7)	
Economic activity					0.664
Employed	33.2 (25.8–41.5)	39.4 (32.6–46.7)	35.8 (30.0–42.1)	39.2 (33.2–45.6)	
Unemployed	66.8 (58.5–74.2)	60.6 (53.3–67.4)	64.2 (57.9–70.0)	60.8 (54.4–66.8)	
Education					0.164
≤ Middle school	65.9 (58.3–72.8)	67.0 (60.2–73.2)	65.0 (59.6–70.0)	50.7 (44.1–57.2)	
High school	20.2 (14.4–27.5)	23.3 (17.8–29.9)	23.0 (18.6–28.1)	28.2 (22.8–34.2)	
≥ College	13.9 (9.4–20.0)	9.7 (6.4–14.3)	12.0 (8.8–16.2)	21.2 (15.8–27.8)	
Household income					0.589
Low	44.5 (36.7–52.5)	45.0 (38.4–51.7)	38.2 (32.8–43.9)	35.7 (30.3–41.6)	
Lower middle	24.2 (18.2–31.5)	20.6 (15.5–26.7)	27.2 (22.4–32.7)	27.8 (22.6–33.6)	
Upper middle	18.3 (13.2–24.8)	14.5 (10.6–19.5)	22.1 (17.2–27.9)	20.0 (15.1–26.1)	
High	13.0 (8.9–18.6)	20.0 (14.7–26.6)	12.5 (9.1–16.9)	16.5 (12.0–22.2)	
Residential area					0.001
Urban	79.4 (72.1–85.2)	80.2 (74.0–85.1)	78.3 (72.3–83.3)	77.5 (71.3–82.8)	
Rural	20.6 (14.8–27.9)	19.8 (14.9–26.0)	21.7 (16.7–27.7)	22.5 (17.2–28.7)	
Health insurance					0.083
Medicare	92.2 (85.9–95.9)	90.4 (84.6–94.1)	88.2 (83.8–91.5)	88.7 (84.6–91.9)	
Medical aid	7.8 (4.1–14.1)	9.6 (5.9–15.4)	11.8 (8.5–16.2)	11.3 (8.1–15.4)	
Self-rated health					0.919
Good	13.1 (8.3–20.0)	10.2 (6.7–15.3)	10.9 (7.6–15.3)	15.8 (11.6–21.2)	
Fair	38.7 (31.7–46.3)	41.9 (35.5–48.6)	38.4 (32.8–44.3)	42.3 (36.3–48.6)	
Poor	48.2 (41.1–55.3)	47.9 (41.3–54.6)	50.7 (44.7–56.7)	41.9 (35.6–48.6)	
Smoking status					0.626
Current smoker	17.8 (12.3–25.0)	16.0 (11.6–21.7)	18.3 (14.0–23.5)	12.9 (9.0–18.1)	
Never/Past smoker	82.2 (75.0–87.7)	84.0 (78.3–88.4)	81.7 (76.5–86.0)	87.1 (81.9–91.0)	
Drinking status					0.348
Risky drinking	6.1 (3.7–10.0)	5.5 (2.9–10.2)	10.7 (7.3–15.5)	10.2 (6.6–15.5)	
Non-risky drinking	93.9 (90.0–96.3)	94.5 (89.8–97.1)	89.3 (84.5–92.7)	89.8 (84.5–93.4)	
Health screening					0.394
Yes	60.8 (52.5–68.6)	68.5 (62.5–73.9)	63.8 (58.0–69.2)	69.2 (63.2–74.6)	
No	39.2 (31.4–47.5)	31.5 (26.1–37.5)	36.2 (30.8–42.0)	30.8 (25.4–36.8)	

CI = confidence interval, SD = standard deviation, BMI = body mass index.

associated with uncontrolled diabetes (aOR, 1.15; 95% CI, 1.03–1.64; $P = 0.010$) compared to high household income (**Table 4**). Participants with non-health screening were significantly associated with uncontrolled hyperlipidemia with a cutoff value of LDL-C < 70 mg/dL (aOR,

Table 2. Age-adjusted trends of achieving goals of risk factor control

Characteristics	2010–2012 (n = 229)	2013–2015 (n = 308)	2016–2018 (n = 371)	2019–2021 (n = 353)	P for trend
Blood pressure < 130/80 mmHg	44.9 (37.4–52.6)	45.6 (38.9–52.5)	45.1 (39.0–51.2)	44.9 (38.6–51.4)	0.957
19–49 yr (n = 75)	50.6 (24.6–76.2)	45.4 (23.2–69.6)	49.4 (35.8–63.1)	32.9 (19.3–50.1)	0.246
50–64 yr (n = 351)	45.3 (33.2–58.0)	43.5 (32.7–55.0)	44.3 (33.6–55.5)	40.7 (28.5–54.3)	0.670
≥ 65 yr (n = 835)	43.8 (34.8–53.2)	47.2 (39.1–55.4)	44.9 (38.0–52.1)	49.7 (42.6–56.9)	0.390
Blood pressure < 140/90 mmHg	74.1 (66.9–80.2)	70.0 (63.1–76.0)	74.8 (69.1–79.7)	78.4 (73.3–82.7)	0.095
19–49 yr (n = 75)	76.1 (47.8–91.7)	90.9 (73.9–97.3)	78.1 (57.1–90.5)	79.7 (66.7–88.6)	0.746
50–64 yr (n = 351)	84.6 (77.0–90.0)	66.1 (54.5–76.0)	80.5 (71.5–87.1)	80.6 (69.7–88.2)	0.410
≥ 65 yr (n = 835)	68.3 (59.5–75.9)	68.9 (60.3–76.4)	70.6 (63.3–77.0)	77.0 (70.4–82.5)	0.064
HbA1c ≤ 7%	83.2 (76.4–88.3)	86.4 (81.0–90.5)	84.3 (79.1–88.4)	88.1 (84.0–91.3)	0.239
19–49 yr (n = 75)	89.9 (50.4–98.7)	82.0 (50.7–95.3)	77.2 (56.6–89.8)	95.2 (70.9–99.4)	0.353
50–64 yr (n = 351)	87.0 (70.2–95.0)	86.1 (76.5–92.2)	87.8 (79.2–93.1)	85.3 (76.2–91.3)	0.882
≥ 65 yr (n = 835)	80.2 (72.0–86.4)	87.5 (81.1–92.0)	83.1 (77.1–87.7)	87.8 (82.6–91.6)	0.180
LDL-C < 70 mg/dL	30.1 (22.2–37.9)	32.1 (25.3–38.8)	40.2 (34.1–46.0)	40.4 (34.1–46.3)	0.015
19–49 yr (n = 75)	47.0 (38.3–54.6)	26.9 (16.3–48.6)	26.4 (19.8–43.8)	15.8 (9.8–35.6)	0.048
50–64 yr (n = 351)	20.0 (15.0–37.2)	34.5 (24.3–44.3)	33.7 (23.5–43.6)	36.9 (23.3–49.5)	0.201
≥ 65 yr (n = 835)	31.7 (23.8–41.4)	31.3 (33.2–49.3)	46.4 (39.6–52.6)	47.7 (31.0–53.9)	< 0.001
Do not smoke during the survey	82.2 (75.0–87.7)	84.0 (78.3–88.4)	81.7 (76.5–86.0)	87.1 (81.9–91.0)	0.260
19–49 yr (n = 75)	71.2 (42.3–89.3)	69.3 (43.0–87.1)	74.8 (55.2–87.7)	78.6 (53.6–92.1)	0.535
50–64 yr (n = 351)	84.6 (72.3–92.0)	78.6 (67.1–86.8)	76.9 (66.9–84.5)	86.6 (78.6–91.9)	0.598
≥ 65 yr (n = 835)	82.7 (74.5–88.7)	90.9 (85.8–94.3)	85.9 (79.6–90.5)	89.3 (84.1–92.9)	0.318

HbA1c = hemoglobin A1c, LDL-C = low-density lipoprotein cholesterol.
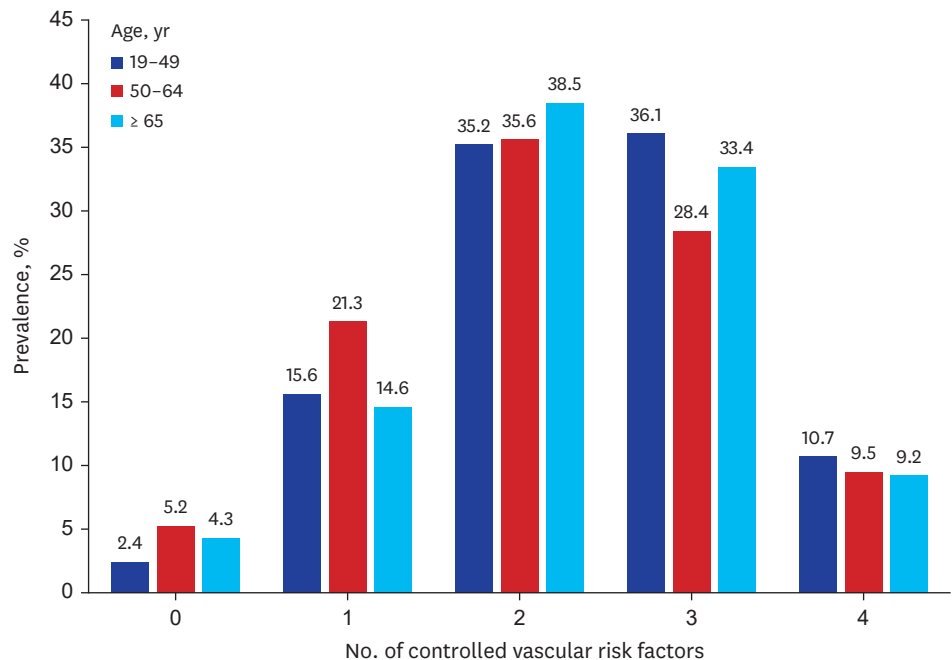
Fig. 1. Prevalence of achieving target goals for vascular risk factors among stroke survivors by age.

2.28; 95% CI, 1.25–4.14; $P = 0.007$). On the contrary, participants aged > 65 years (aOR, 0.51; 95% CI, 0.18–0.92; $P = 0.031$) and those with diabetes mellitus (aOR, 0.45; 95% CI, 0.24–0.84; $P = 0.012$) had well-controlled hyperlipidemia (**Table 5**). In terms of smoking, there was a clear and significant association with men (aOR, 4.47; 95% CI, 3.12–6.72; $P < 0.001$) compared to women (**Table 6**).

Table 3. Factors associated with uncontrolled hypertension

Characteristics	Unadjusted OR (95% CI)	P value	Adjusted OR (95% CI)	P value
Age, yr				
19–49			Ref.	
50–64	0.95 (0.32–2.84)	0.923		
≥ 65	1.18 (0.43–3.21)	0.752		
Male sex	0.94 (0.54–1.64)	0.831		
BMI, kg/m²				
< 18.5			Ref.	
18.5–24.9	2.83 (0.31–26.07)	0.358		
≥ 25	3.51 (0.38–32.33)	0.267		
Vascular risk factors				
Diabetes	1.65 (0.91–3.00)	0.102		
Dyslipidemia	1.06 (0.60–1.87)	0.852		
Without spouse	1.92 (1.07–3.43)	0.028	1.85 (1.03–3.32)	0.038
No. of family members				
1	1.73 (0.64–4.72)	0.283		
2	1.05 (0.40–2.73)	0.920		
3	1.60 (0.52–4.92)	0.415		
4			Ref.	
Non-economic activity	0.95 (0.54–1.67)	0.856		
Education				
≤ Middle school	1.09 (0.50–2.38)	0.827		
High school	0.89 (0.37–2.17)	0.801		
Above college			Ref.	
Household income				
Low	1.31 (0.54–3.18)	0.547		
Lower middle	0.99 (0.37–2.67)	0.982		
Upper middle	1.03 (0.37–2.88)	0.959		
High			Ref.	
Living in an urban area	1.14 (0.61–2.13)	0.677		
Medical aid	1.60 (0.73–3.49)	0.237		
Self-rated health				
Good	0.41 (0.16–1.08)	0.071	0.45 (0.17–1.19)	0.107
Fair			Ref.	
Poor	0.72 (0.39–1.34)	0.300	0.70 (0.38–1.29)	0.249
Current smoking	0.73 (0.28–1.88)	0.517		
Non-high risk drinking	1.20 (0.36–4.05)	0.767		
Non-health screening	1.32 (0.70–2.49)	0.387		

OR = odds ratio, CI = confidence interval, BMI = body mass index.

DISCUSSION

This study analyzed KNHANES data to assess the management of key VRFs, including hypertension, diabetes, hyperlipidemia, and smoking, among stroke survivors in South Korea over 11 years. The results indicated that although there have been some improvements in managing these risk factors, significant gaps remain, particularly in younger age groups and specific demographic segments. These findings highlight the importance of targeted interventions to address these gaps.

Recurrent strokes pose a significant health threat, often resulting in more severe disabilities and higher mortality rates compared to first-time strokes.[15] Managing VRFs is crucial for preventing these recurrent events.[5] Although advances in pharmacotherapy may have enhanced our ability to control these risk factors,[16,17] our analysis revealed that only 9.4% of stroke survivors had all four key VRFs under control. This indicates that the overall control of these risk factors remains suboptimal. Efforts must focus on increasing stroke awareness, motivating behavioral changes, and improving patient adherence to treatment protocols.[18]

Table 4. Factors associated with uncontrolled diabetes

Characteristics	Unadjusted OR (95% CI)	P value	Adjusted OR (95% CI)	P value
Age, yr				
19–49			Ref.	
50–64	3.42 (0.42–28.13)	0.252		
≥ 65	2.75 (0.34–21.97)	0.339		
Male sex	1.16 (0.58–2.34)	0.670		
BMI, kg/m²				
< 18.5			Ref.	
18.5–24.9	1.91 (0.21–17.14)	0.562		
≥ 25	2.33 (0.25–21.71)	0.457		
Vascular risk factors				
Hypertension	1.02 (0.47–2.22)	0.957		
Dyslipidemia	1.76 (0.85–3.64)	0.127		
Without spouse	1.28 (0.63–2.61)	0.497		
No. of family members				
1	1.80 (0.47–6.87)	0.387	1.71 (0.41–7.11)	0.459
2	3.07 (0.98–9.59)	0.054	2.88 (0.91–9.11)	0.071
3	1.29 (0.30–5.49)	0.732	0.96 (0.22–4.19)	0.961
4			Ref.	
Non-economic activity	0.86 (0.44–1.71)	0.677		
Education				
≤ Middle school	1.56 (0.56–4.37)	0.398		
High school	1.30 (0.39–4.30)	0.668		
Above college			Ref.	
Household income				
Low	0.77 (0.23–2.51)	0.660	1.60 (0.17–2.12)	0.428
Lower middle	1.74 (0.54–5.60)	0.351	1.28 (0.38–4.24)	0.691
Upper middle	1.20 (1.05–1.85)	0.029	1.15 (1.03–1.64)	0.010
High			Ref.	
Living in an urban area	2.40 (0.95–6.02)	0.063	2.75 (1.06–7.17)	0.038
Medical aid	1.12 (0.46–2.75)	0.804		
Self-rated health				
Good	0.77 (0.26–2.30)	0.640		
Fair			Ref.	
Poor	1.78 (0.86–3.71)	0.122		
Current smoking	0.66 (0.24–1.82)	0.421		
Non-high-risk drinking	0.99 (0.25–3.88)	0.989		
Non health screening	1.03 (0.48–2.19)	0.947		

OR = odds ratio, CI = confidence interval, BMI = body mass index.

Monitoring trends and identifying vulnerable populations with poor control of these factors are essential steps in crafting targeted interventions that can effectively reduce the risk of stroke recurrence.

One of the critical findings of this study was the age-related divergence in the management of hyperlipidemia. During the observation period, the target goal for hyperlipidemia was decreased LDL-C levels. Thus, it can be inferred that the overall control rate of LDL-C levels increased. However, while control of LDL-C levels improved over time in older adults, it worsened in younger stroke survivors. Specifically, LDL-C target achievement increased significantly among those aged ≥ 65 years but decreased notably in the 19–49 age group. This trend is concerning, as it may reflect lifestyle changes among younger individuals, such as dietary habits or reduced physical activity, which could contribute to poorer lipid control.[19,20] The worsening of hyperlipidemia control in younger age groups could have significant implications for public health, as it may increase the risk of stroke recurrence in these individuals.

Table 5. Factors associated with uncontrolled hyperlipidemia

Characteristics	Unadjusted OR (95% CI)	P value	Adjusted OR (95% CI)	P value
Age, yr				
19–49		Ref.		
50–64	0.42 (0.14–1.27)	0.125	0.68 (0.23–2.05)	0.498
≥ 65	0.27 (0.10–0.70)	0.008	0.51 (0.18–0.92)	0.031
Male sex	0.90 (0.53–1.53)	0.696		
BMI, kg/m²				
< 18.5				
18.5–24.9	0.32 (0.06–1.79)	0.196		
≥ 25	0.35 (0.06–2.05)	0.247		
Vascular risk factors				
Hypertension	0.50 (0.28–0.90)	0.020	0.62 (0.33–1.16)	0.135
Diabetes	0.39 (0.21–0.72)	0.002	0.45 (0.24–0.84)	0.012
Without spouse	0.80 (0.47–1.36)	0.411		
No. of family members				
1	0.76 (0.31–1.88)	0.557		
2	0.67 (0.30–1.50)	0.330		
3	1.00 (0.38–2.62)	0.995		
> 4		Ref.		
Non-economic activity	0.60 (0.35–1.02)	0.058	0.76 (0.42–1.41)	0.389
Education				
≤ Middle school	0.42 (0.20–0.84)	0.015	0.77 (0.32–1.86)	0.567
High school	0.58 (0.27–1.22)	0.150	0.77 (0.34–1.73)	0.521
College		Ref.		
Household income				
Low	0.42 (0.18–0.97)	0.043	0.66 (0.25–1.71)	0.392
Lower middle	0.90 (0.39–2.10)	0.811	1.31 (0.53–3.27)	0.557
Upper middle	1.06 (0.41–2.74)	0.898	1.10 (0.43–2.81)	0.846
High		Ref.		
Living in urban area	1.23 (0.70–2.15)	0.468		
Medical aid	0.62 (0.28–1.36)	0.233		
Self-rated health				
Good	1.39 (0.64–3.01)	0.400		
Fair		Ref.		
Poor	1.32 (0.73–2.38)	0.352		
Current smoking	0.94 (0.39–2.23)	0.880		
Non-high-risk drinking	0.56 (0.24–1.29)	0.172		
Non-health screening	1.85 (1.06–3.24)	0.031	2.28 (1.25–4.14)	0.007

OR = odds ratio, CI = confidence interval, BMI = body mass index.

Notably, a continuing trend in smoking was observed among male stroke survivors. Despite public health campaigns and efforts to reduce smoking rates, this study found that the number of participants who quit smoking or stayed smoke-free did not improve significantly over the study period, particularly among male stroke survivors.[21,22] This stagnation could be due to several factors, including cultural attitudes toward smoking, stress-related smoking behaviors, and inadequate support for smoking cessation programs targeting men. Since smoking is a significant risk factor for stroke recurrence,[23] this finding highlights the need for more effective interventions to help male stroke survivors quit smoking.

This study identified several factors associated with uncontrolled VRFs. For example, living alone without a spouse was significantly associated with uncontrolled hypertension, whereas living in urban areas was associated with uncontrolled diabetes. These findings suggest that social and environmental factors are crucial in managing vascular risk.[24,25] Diabetes control was also associated with household income. Diabetes was less likely to be controlled in the middle- and low-income groups than in the high-income group. Furthermore, the lower the household income, the more uncontrolled was the diabetes. This highlights the impact of

Table 6. Factors associated with smoking after the diagnosis of stroke

Characteristics	Unadjusted OR (95% CI)	P value	Adjusted OR (95% CI)	P value
Age, yr				
19–49			Ref.	
50–64	0.57 (0.15–2.18)	0.409		
≥ 65	0.44 (0.13–1.47)	0.184		
Male sex	8.03 (2.98–21.62)	< 0.001	4.47 (3.12–6.72)	< 0.001
BMI, kg/m²				
< 18.5			Ref.	
18.5–24.9	0.90 (0.15–5.37)	0.909		
≥ 25	0.45 (0.07–2.96)	0.403		
Vascular risk factors				
Hypertension	0.72 (0.32–1.62)	0.431		
Diabetes mellitus	0.59 (0.25–1.35)	0.208		
Dyslipidemia	0.77 (0.37–1.60)	0.480		
Without spouse	0.93 (0.44–1.99)	0.854		
No. of family members				
1	0.34 (0.10–1.14)	0.081	0.38 (0.10–1.40)	0.145
2	0.45 (0.15–1.37)	0.160	0.50 (0.15–1.62)	0.249
3	0.48 (0.12–1.96)	0.306	0.62 (0.13–2.85)	0.538
> 4			Ref.	
Non-economic activity	0.68 (0.31–1.51)	0.347		
Education (Ref.: ≥ College)				
≤ Middle school	0.79 (0.25–2.47)	0.688		
High school	0.93 (0.26–3.27)	0.905		
Above college				
Household income			Ref.	
Low	2.21 (0.54–9.07)	0.272		
Lower middle	2.12 (0.55–8.24)	0.277		
Upper middle	3.11 (0.69–14.01)	0.139		
High			Ref.	
Living in an urban area	0.52 (0.25–1.11)	0.091	0.53 (0.25–1.12)	0.096
Medical aid	1.23 (0.48–3.14)	0.659		
Self-rated health (Ref.: Fair)				
Good	0.78 (0.26–2.32)	0.651		
Fair			Ref.	
Poor	1.22 (0.58–2.60)	0.600		
Non-high risk drinking	0.41 (0.15–1.13)	0.086	0.52 (0.18–1.55)	0.243
Non-health screening	1.29 (0.54–3.08)	0.562		

OR = odds ratio, CI = confidence interval, BMI = body mass index.

socio-economic status on health outcomes.[26] Finally, the lack of regular health screenings was associated with poor control of hyperlipidemia, emphasizing the importance of routine health monitoring in managing chronic conditions.[27]

This study had some limitations. First, the cross-sectional design of the KNHANES did not allow us to uncover causal relationships between variables. Second, the reliance on self-reported data for stroke diagnosis and smoking status may introduce a recall bias, potentially affecting the accuracy of the findings. Additionally, the study may not have avoided the potential influence of unmeasured confounding factors, such as medication adherence or access to healthcare services, which could affect the control of VRFs.

In conclusion, this study highlights the ongoing challenges in managing VRFs in stroke survivors in South Korea. Although improvements have been made in certain areas, significant gaps remain. These findings underscore the need for targeted interventions to address these disparities to reduce the risk of stroke recurrence.

SUPPLEMENTARY MATERIALS

Supplemental Table 1
Sex-adjusted trends of achieving risk factor control goals

Supplemental Fig. 1
Patient flow chart.

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