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ORIGINAL ARTICLE

Determinants of stroke prevalence in the southeastern region of the United States

Daudet Ilunga Tshiswaka[1] · Kelechi D. Ibe-Lamberts[2] · Michael Fazio[3] · John Derek Morgan[4] · Courtney Cook[5] · Peter Memiah[1]

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Abstract

Purpose The southeast of the United States (USA) is a high stroke prevalence area otherwise known as the "Stroke Belt" in order to characterize the increased stroke morbidity and mortality rates found there. The purpose of this study was to characterize the relationship between socio-cultural factors and dietary habits related to stroke occurrence within the affected states.

Methods The 2015 Behavioral Risk Factor Surveillance System (BRFSS) data was analyzed for both bivariate and multivariate models aimed at studying the interaction between socio-cultural factors and the prevalence pattern of stroke in the southeastern area of the USA.

Results Overall, 4% of individuals who lived in the US southeastern states of Alabama, Florida, Georgia, Louisiana, and Mississippi had stroke. Of these, Mississippi had the most stroke victims, followed by Alabama, Louisiana, Georgia, and Florida, with 5.1%, 4.7%, 4.5%, 4.3%, and 3.4% respectively ($\chi^2 = 18.68$ and p value < 0.01). The logistic regression showed that individuals who consumed vegetables every day were less likely to be stroke victims than those who did not consume vegetables on a daily basis, with aOR = 0.74; CI = 0.59–0.91; p value < 0.01. Surprisingly, individuals who drank alcohol were less likely to report stroke than those who did not drink alcohol (aOR = 0.63; CI = 0.51–0.79; p value < 0.001).

Conclusion Characterization of factors associated with stroke prevalence in a region of the USA known for its adverse stroke rates is essential for offsetting the burden of this public health issue and for promoting health.

Keywords Stroke · Southeastern USA · Stroke Belt · Risk factor · Prevalence

Introduction

In the United States (USA), stroke is responsible for one out of every 20 deaths, totaling over 130,000 cases each year and costing $33 billion in direct and indirect costs between 2011 and 2012 (CDC 2016; Mozaffarian et al. 2016). Stroke prevalence varies among different locations and demographics. Data between 2006 and 2010 showed higher stroke rates in the southeastern USA, and among people who were older adults, Black, and or had a lower level of education (Mozaffarian et al. 2016). The southeastern USA, aptly named the "Stroke Belt", is a region that has been recognized since 1940 for having a high prevalence of stroke and a mortality rate that has been shown to be roughly 20% higher than the rest of the USA (Karp et al. 2016; Mozaffarian et al. 2016).

Stroke can be caused by a number of different modifiable and non-modifiable factors, but a recent study showed that nearly 90% of stroke incidences could have been a result of one of the following risk factors: hypertension, diabetes, cardiac causes, smoking, obesity, hyperlipidemia, physical inactivity, consumption of alcohol, diet, and psychological stress and depression (Ovbiagele and Nguyen-Huynh 2011). In

✉ Daudet Ilunga Tshiswaka
daudeti@uwf.edu

1 Department of Public Health, University of West Florida, 11000 University Parkway, Pensacola, FL 32514, USA

2 Health Department, SUNY Cortland, Cortland, NY 13045, USA

3 Department of Earth and Environmental Science, University of West Florida, GeoData-Center, Pensacola, FL 32514, USA

4 Department of Earth and Environmental Science, University of West Florida, Pensacola, FL 32514, USA

5 Department of Biology, University of West Florida, Pensacola, FL 32514, USA

contrast, stroke can also be attributed to other, less controllable, risk factors such as age, gender, race, geographic location, and genetics (Ovbiagele and Nguyen-Huynh 2011).

The high stroke prevalence in the southeastern USA is not a well-understood phenomenon and has been attributed to a combination of multiple factors. Studies have shown that the presence of a) a large Black population, b) people of lower socio-economic status, and c) higher rates of behavioral factors related to stroke could be partly to blame (Karp et al. 2016; Siegel et al. 1992) compared to non-Stroke Belt states. When combined, these factors were shown to account for approximately three-quarters of the excess prevalence witnessed in the Stroke Belt states (Liao et al. 2009). These observations are consistent with other findings from intra-Stroke Belt studies. For instance, a study in Georgia reported that an increased risk for cardiovascular disease in women was inversely related to socio-economic indicators such as education level, employment status, and level of income (Davis et al. 2014). Similarly, people in middle Tennessee with lower levels of education were much more likely to experience stroke than those who obtained higher education (Odoi and Busingye 2014). Furthermore, some studies suggested that genetics, differing responses to antihypertensive drugs, and environmental toxicity are probably contributing factors to stroke; however, these determinants lack sufficient evidence to gain significant standing as leading causes (Perry and Roccella 1998).

Geographically, stroke prevalence in the southeastern region is well documented as being significantly higher than the rest of the USA (Karp et al. 2016; Mozaffarian et al. 2016; Siegel et al. 1992). The states that define the Stroke Belt vary by study but have included as many as eleven states (Siegel et al. 1992) or as few as eight (Karp et al. 2016). While many of the 'core' Stroke Belt states are well agreed upon, Florida is almost always excluded. This inaccuracy is likely because, historically, most definitions have been developed at the state level as opposed to higher geographic resolutions such as the county level. In support of this argument, when stroke mortality rates were calculated for Florida counties, 49% of them showed higher rates than the national rate, and one-third of them fell above the "Stroke Belt threshold" value of 44.3 per 100,000 people (Siegel et al. 1992). The underlying causes of these geographic disparities are not well understood, but could be attributed to socio-economic status, demographics, and access to healthcare facilities (Karp et al. 2016; Odoi and Busingye 2014).

To better understand the potential underlying factors of these geographic stroke discrepancies, our study aims to investigate the relationships between socio-cultural factors and the prevalence of stroke in individuals living in the USA southeastern area.

Method

Data collection and participants

We performed a secondary data analysis using the Behavioral Risk Factor Surveillance System (BRFSS) survey conducted in 2015. The BRFSS is a statewide survey conducted by the Centers for Disease Control and Prevention via telephone, and includes information related to health-risk behaviors and chronic diseases, as well as preventive practices such as physical activity and dietary habits (CDC 2015). These factors were analyzed for five of the highest stroke prevalence states, including Louisiana, Mississippi, Alabama, Georgia, and Florida in order to gain a better understanding of the underlying factors contributing to this regional phenomenon found in the southeastern USA.

Measures and statistical analysis

Descriptive, bivariate, and multivariate analyses were performed using Stata 14 statistical software. We applied weighting to allow for the representativeness of the findings in the southeastern region (Applied Survey Methods 2017). The weighted sample size was 18,281,553 individuals with sixteen variables relevant to stroke prevalence and incidence (Sacco 1995). Specifically, with *stroke status* (dichotomous variable) as a dependent variable, independent variables included nine categorical variables such as *gender* (male or female), *race* (White, Black, Hispanic, and Other), *regions/states* (Alabama, Florida, Georgia, Louisiana, and Mississippi), *education level* (less than high school, high school diploma, college or vocational school, and bachelor degree), *income level* (less than \$15,000, \$15,000–\$24,999, \$25,000–\$34,999, \$35,000–\$49,999, \$50,000 or more), *age* (18–24 years, 25–34, 35–44, 45–54, 55–64, 65 or older), *marital status* (married/unmarried; the unmarried category consisted of divorced, widowed, separated, never married and a member of an unmarried couple), *smoking status* (current smoker, former smoker, and never smoked; current smokers referred to individuals who smoked every day or some days, while former smokers related to those who had stopped smoking in the past 12 months), and *BMI level* (underweight or $BMI < 18.5$, normal or $18.5 \leq BMI < 25.0$, overweight or $25.0 \leq BMI < 30.0$, and obese or $BMI \geq 30.0$).

The analysis also included seven dichotomous variables: *alcohol consumption* (at least one alcoholic drink consumed in the past 30 days vs no alcohol consumed in the past 30 days), *fruit consumption per day* ("yes" indicating the consumption of fruit one or more times per day and "no" otherwise), *vegetable consumption per day* ("yes" for consumption of vegetables one or more times per day and "no" otherwise), *physical activity* ("yes" indicating physical activity or exercise in the last 30 days and "no" otherwise), *high cholesterol levels* ("yes" if respondent had been told by a doctor, nurse, or other health professional that their blood cholesterol was high and "no" otherwise), *diabetes* ("yes" if respondent had diabetes or "no" if they did not), and *high blood pressure* ("yes" indicating high blood pressure and "no" if not). Diabetes and high blood pressure were the only chronic conditions associated with stroke that could be found in the BRFSS dataset (CDC 2015; National Heart, Lung, and Blood Institute 2017). All missing responses and "do not know" or "not sure" options were removed from the analyses.

Results

Overall, the descriptive analysis indicated that 4% of individuals who lived in the five high-prevalence USA southeastern states had reported a stroke event as of 2015 (Table 1). Of these, Mississippi reported the most stroke victims, followed by Alabama, Louisiana, Georgia, and Florida, with 5.1%, 4.7%, 4.5%, 4.3%, and 3.4% respectively ($\chi^2 = 18.68$ and p value < 0.01). The respondents mean age ± SD was 58.3 ± 15.2 years, with a range of 18–80 years.

In terms of non-modifiable stroke factors, more Black respondents (4.5%) reported stroke events than Whites (4.2%) or Hispanics (1.5%) ($\chi^2 = 42.06$; p value < 0.001). The age variable showed an ascending pattern in relation to stroke events ($\chi^2 = 386.74$ and p value < 0.001) and that the prevalence of stroke increased as age advanced.

As for the modifiable factors, education level showed an inverse relationship with the rates of stroke, specifically that as the education level increased, the rates of stroke decreased ($\chi^2 = 117.62$ and p value < 0.001). A similar tendency was observed with the income variable, indicating that increased income was associated with decreased stroke rates ($\chi^2 = 290.02$ and p value < 0.001). With regard to marital status, non-married people (4.8%) reported stroke more often than married people (3.3%) ($\chi^2 = 25.50$ and p value < 0.01). Additionally, 6.3% of current smokers were stroke victims compared to 2.8% of those who had never smoked ($\chi^2 = 102.83$ and p value < 0.001). Surprisingly, fewer respondents who consumed alcohol reported stroke than those who did not consume alcohol (2.4% vs 5.6% respectively. $\chi^2 = 130.22$ and p value < 0.001). More individuals who reported no *fruit consumption per day* (4.6%) reported stroke compared to those who did (3.5%) ($\chi^2 = 16.39$ and p value < 0.01); the same applied for individuals who reported no *vegetable consumption per day* (6%) compared to those who did (3.4%) ($\chi^2 = 60.02$ and p value < 0.001). Furthermore, more respondents with sedentary lifestyles (6.7%) reported stroke events than those who engaged in physical activity (3%) ($\chi^2 = 130.13$ and p value < 0.001). Likewise, more individuals with high cholesterol levels (6.7%) were stroke victims compared to those who did not report elevated cholesterol levels (2.2%), ($\chi^2 = 246.63$ and p value < 0.001).

Table 1 Bivariate analyses of stroke status in the southeast of the USA

	Stroke status	
	$N = 18{,}281{,}553$	
	Yes (4%)	No (96%)
Gender		
Male	3.8	96.2
Female	4.1	95.9
$\chi^2 = 1.21$		
Race***		
White	4.2	95.8
Black	4.5	95.5
Hispanic	1.5	98.5
Other	4.3	95.7
$\chi^2 = 42.06$		
Region/State**		
Alabama	4.7	95.3
Florida	3.4	96.6
Georgia	4.3	95.7
Louisiana	4.5	95.5
Mississippi	5.1	94.9
$\chi^2 = 18.68$		
Education level***		
Less than high school	6.9	93.1
High school diploma	5	95
College or vocational school	3.8	96.2
Bachelor degree	2.1	97.9
$\chi^2 = 117.62$		
Income level***		
< $15,000	8.9	91.1
$15,000–$24,999	6.3	93.7
$25,000–$34,999	5.6	94.4
$35,000–$49,999	3.2	96.8
≥ $50,000	1.9	98.1
$\chi^2 = 290.02$		
Age group (years)***		
18–24	0	100
25–34	0.9	99.1
35–44	1	99
45–54	3.5	96.5
55–64	6	94
65 or older	7.5	92.5
$\chi^2 = 386.74$		
Marital status**		
Married	3.3	96.7
Unmarried	4.8	95.2
$\chi^2 = 25.50$		
Smoking status***		
Current smoker	6.3	93.7
Former smoker	5	95

Table 1 (continued)

	Stroke status	
	$N = 18,281,553$	
	Yes (4%)	No (96%)
Never smoked	2.8	97.2
$\chi^2 = 102.83$		
Alcohol consumption in past 30 days***		
Yes	2.4	97.6
No	5.6	94.4
$\chi^2 = 130.22$		
Fruit consumption, daily**		
Yes	3.5	96.5
No	4.6	95.4
$\chi^2 = 16.39$		
Vegetable consumption, daily***		
Yes	3.4	96.6
No	6	94
$\chi^2 = 60.02$		
Physical activity in past 30 days***		
Yes	3	97
No	6.7	93.3
$\chi^2 = 130.13$		
High cholesterol***		
Yes	6.7	93.3
No	2.2	97.8
$\chi^2 = 246.63$		
Diabetes***		
Yes	8.6	91.4
No	3.1	96.9
$\chi^2 = 212.87$		
High blood pressure***		
Yes	7.6	92.4
No	1.4	98.6
$\chi^2 = 473.98$		
BMI level		
Underweight	4.4	95.6
Normal	3.8	96.2
Overweight	3.8	96.2
Obese	4.4	95.6
$\chi^2 = 5.07$		

****p* value < 0.001; ***p* value < 0.01

With regard to chronic conditions such as diabetes and high blood pressure, 8.6% of diabetic individuals reported stroke events compared to 3.1% of individuals without diabetes ($\chi^2 = 212.87$ and p value < 0.001). Hypertensive respondents (7.6%) were also more often stroke victims than those who did not have high blood pressure (1.4%) ($\chi^2 = 473.98$ and p value < 0.001).

Logistic regression—reported in Table 2—omitted the *age* variable in the model because of missing values in one category and collinearity. None of the interaction terms yielded statistically significant results. Overall, the current model indicated that Hispanic respondents were less likely to be stroke victims than White individuals (aOR = 0.40; CI = 0.23–0.72; p value < 0.01). The same pattern was observed among individuals earning more than $35,000, who had a lesser likelihood of being stroke victims compared to individuals earning $15,000 or less. In addition, those who had never smoked were less likely to be stroke victims than those who were current smokers (aOR = 0.58; CI = 0.45–0.75; p value < 0.001).

With respect to other lifestyle factors, we found that individuals who drank alcohol were less likely to report stroke than those who did not drink alcohol (aOR = 0.63; CI = 0.51–0.79; p value < 0.001). As expected, respondents who consumed vegetables on a daily basis were less likely to be stroke victims compared to those who did not eat vegetables every day (aOR = 0.74; CI = 0.59–0.91; p value < 0.01). Respondents who participated in physical activity on a monthly basis were less likely to report stroke than those who did not (aOR = 0.73; CI = 0.60–0.90; p value < 0.01). Unsurprisingly, respondents who reported high cholesterol levels were more likely to be stroke victims compared to those who did not (aOR = 1.75; CI = 1.39–2.19; p value < 0.001).

With regard to chronic conditions, diabetic individuals were more likely to be stroke victims than those who did not have diabetes (aOR = 1.43; CI = 1.15–1.78; p value < 0.01). Likewise, respondents with high blood pressure had a higher probability of being stroke victims compared to those who did not (aOR = 3.60; CI = 2.80–4.64; p value < 0.001).

Predicted probabilities of statistically significant variables in the logistic regression model are presented in the figures below. Specifically, Fig. 1 displays the predicted probabilities of stroke status for physical activity participation, high cholesterol levels, and daily vegetable consumption across age for males and females. In general, a female aged less than 65 years who did not exercise, had high cholesterol levels, or did not consume vegetables daily presented relatively high predicted probabilities of being a stroke victim compared to a male individual. Conversely, at age 65 years or older, most males who were sedentary, had high cholesterol levels, or did not consume vegetables daily presented higher predicted probabilities of having stroke than females in the same age category.

Similarly, Fig. 2 below shows the predictions of stroke status for diabetes and high blood pressure statuses across age for male and female respondents in the southeastern USA. Again, a female aged less than 65 years with diabetes or high blood pressure displayed a higher predicted probability of being a stroke victim than her male counterpart. Inversely, a male aged more than 65 years who was diabetic or had high blood pressure presented higher predicted probabilities of being a stroke victim compared to a female with the same conditions.

Table 2 Logistic regression model of stroke probability among individuals living in the southeast of the USA

	aOR*	95% CI	*P* value
Gender			
Male (ref)	1		
Female	1.03	0.84–1.25	NS
Race			
White (ref)	1		
Black	0.85	0.65–1.10	NS
Hispanic	0.40	0.23–0.72	< 0.01
Other	1.13	0.64–1.99	NS
Region/State			
Alabama (ref)	1		
Florida	0.99	0.77–1.27	NS
Georgia	1.07	0.80–1.42	NS
Louisiana	0.95	0.73–1.24	NS
Mississippi	0.96	0.74–1.24	NS
Education level			
Less than high school (ref)	1		
High school diploma	1.04	0.78–1.40	NS
College or vocational school	1.07	0.79–1.45	NS
Bachelor degree	0.96	0.69–1.33	NS
Income level			
<$15,000 (ref)	1		
$15,000–$24,999	0.83	0.63–1.10	NS
$25,000–$34,999	0.87	0.61–1.25	NS
$35,000–$49,999	0.54	0.37–0.80	< 0.01
≥ $50,000	0.39	0.27–0.57	< 0.001
Marital status			
Married (ref)	1		
Unmarried	1.01	0.80–1.26	NS
Smoking status			
Current smoker (ref)	1		
Former smoker	0.83	0.63–1.07	NS
Never smoked	0.58	0.45–0.75	< 0.001
Alcohol consumption			
No (ref)	1		
Yes	0.63	0.51–0.79	< 0.001
Fruit consumption, daily			
No (ref)	1		
Yes	0.96	0.78–1.17	NS
Vegetable consumption, daily			
No (ref)	1		
Yes	0.74	0.59–0.91	< 0.01
Physical activity			
No (ref)	1		
Yes	0.73	0.60–0.90	< 0.01
High cholesterol			
No (ref)	1		
Yes	1.75	1.39–2.19	< 0.001
Diabetes			
No (ref)	1		
Yes	1.43	1.15–1.78	< 0.01
High blood pressure			
No (ref)	1		
Yes	3.60	2.80–4.64	< 0.001
BMI level			
Underweight (ref)	1		
Normal	1.09	0.57–2.08	NS
Overweight	0.86	0.45–1.63	NS
Obese	0.68	0.36–1.30	NS
Interactions			
Alcohol and vegetable consumption	0.82	0.60–1.08	NS
Alcohol and physical activity	0.76	0.58–1.01	NS
Alcohol and high cholesterol	1.29	0.98–1.72	NS
Alcohol and diabetes	1.09	0.82–1.47	NS
Alcohol and high blood pressure	1.12	0.82–1.53	NS

aOR*: adjusted odds ratio; NS: not significant

Discussion

The determinants of stroke are well documented in the research literature; however, the geographical disparities have never been determined by researchers (El-Saed et al. 2006; Wetmore et al. 2013). The present study delineates how modifiable and non-modifiable factors affect stroke prevalence for individuals in the southeastern region of the USA.

Study findings have revealed variations in stroke reports among people of different races. Individuals who identified as Black experienced more stroke events than their counterparts from other racial backgrounds. This finding can be attributed to chronic diseases and negative determinants of health associated with stroke that are prevalent in the Black community (i.e., low socio-economic status, high blood pressure, obesity, diabetes, and physical inactivity) (CDC 2005; Howard et al. 2016; Signorello et al. 2014). A similar study by Sacco et al. (1998) demonstrated that racial differences in stroke prevalence were due to the pervasiveness of other related risk factors that are widespread in Black populations. Age was also a non-modifiable factor found to be associated with the prevalence of stroke. This discovery is well corroborated by multiple studies that associate aging with high risks for multiple chronic ailments (Kennedy et al. 2014; Park et al. 2015).

The present study also identified unhealthy behaviors as crucial factors to stroke reports in the Stroke Belt. Individuals who smoked, maintained a sedentary lifestyle, and sustained unhealthy dietary habits reported higher stroke

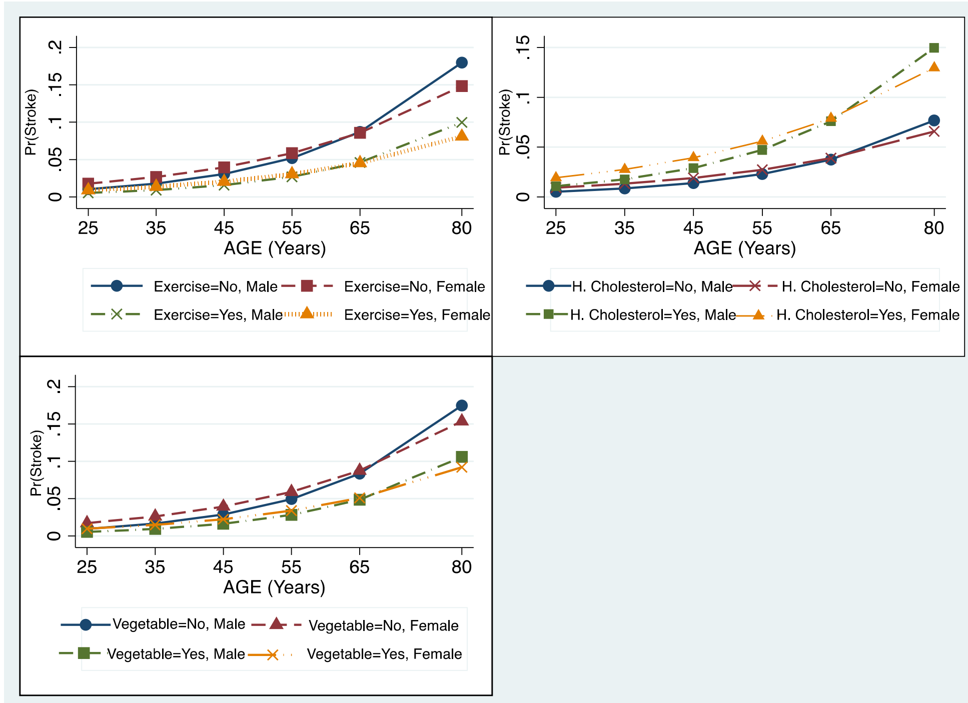

Fig. 1 Adjusted predictions of stroke status for physical activity, high cholesterol, and daily vegetable consumption by gender and age

rates compared to their counterparts. These results are congruent with similar studies that acknowledge a positive association between unhealthy practices and increased risk for stroke. A report by Gutierrez and Williams (2014) noted that stroke prevalence was greater among individuals who engaged in unhealthy behaviors and exhibited uncontrolled

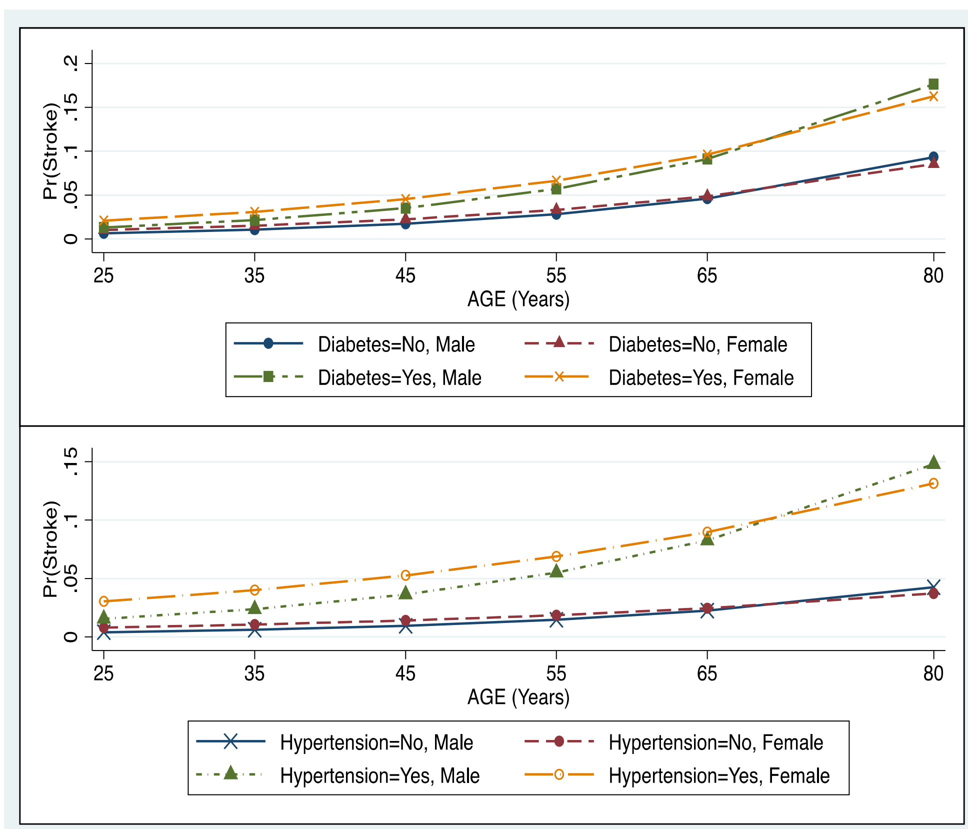

Fig. 2 Adjusted predictions of stroke status for diabetes and high blood pressure by gender and age

hypertension. As expected, individuals suffering from chronic ailments, especially cardiovascular ones such as hypertension, were more likely to suffer a stroke compared to individuals who did not suffer from any. Similar studies on stroke verify this assumption, highlighting the common risk factors shared between stroke and other chronic conditions such as diabetes, obesity, and coronary heart disease (Liao et al. 2009; Seliger et al. 2003).

The insights gained from the present study further emphasize the need for stronger health promotion and intervention efforts within the Stroke Belt. This is also substantiated by multiple other studies reporting high rates of obesity, hypertension, and low socio-economic status among individuals who resided in this region (El-Saed et al. 2006; Spence and Hammond 2016). The reported risk factors associated with stroke are modifiable and can be mitigated through interventions (Kahn et al. 2008; Liao et al. 2009). It is projected that approximately 4% of the USA will have suffered a stroke event by the year 2030 (Ovbiagele et al. 2013)—with the southeastern region accounting for the majority of victims. On the other hand, it is proven that engaging in a healthier lifestyle minimizes the chances of a stroke occurring (Chiuve et al. 2008). This further accentuates the need for public health initiatives and primary prevention programs to reduce the stroke burden in the Stroke Belt. Enhanced prevalence for stroke occurs in this region due to the development and permeation of risk factor behaviors that can be prevented (or eliminated) through interventions centered on altering these particular tendencies.

Limitations

Limitations of this study include the analysis of secondary data, which is only possible for the available collected variables. In other words, some important variables could have been omitted by those who crafted the questionnaire. Furthermore, inherent to secondary data analysis is the potential for recall and/or social desirability biases, based on the possibility that respondents did not clearly remember the information regarding what was asked, or may have answered in a way they presumed might satisfy the interviewer(s).

Conclusion

Socio-cultural determinants—influenced by modifiable factors such as smoking status, level of physical activity, or eating habits, and non-modifiable aspects such as gender, age, and race—can both increase and decrease the prevalence of stroke. In particular, non-modifiable issues have played a role in spawning regions like the Stroke Belt with its greater predisposition to develop certain chronic conditions in people, while unchanged modifiable factors play a role in the likelihood of increased numbers of stroke cases. To reduce the gap of stroke prevalence in the Stroke Belt compared to the rest of the USA, advocacy to promote and induce progress toward healthier lifestyle habits and changes is needed. At minimum, access to resources should be expanded and promoted not only across the Stroke Belt, but also in similar areas where the local demographics are comparable.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest with respect to the research, authorship, and/or publication of this article.

Ethical statement All procedures performed in this study involving human participants were in accordance with the ethical standards of the institution and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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