Received: 12 May 2022 | Revised: 7 November 2022 | Accepted: 9 November 2022

DOI: 10.1002/ajim.23446

RESEARCH ARTICLE

AMERICAN JOURNAL OF INDUSTRIAL MEDICINE WILEY

Duration of employment within occupations and incident stroke in a US general population cohort 45 years of age or older (REGARDS study)

Tran B. Huynh PhD, CIH[1] | Leslie A. McClure PhD[2] | Virginia J. Howard PhD[3] | Monika M. Stafford MD[4] | Suzanne E. Judd PhD[5] | Igor Burstyn PhD[1]

[1]Department of Environmental and Occupational Health, Dornsife School of Public Health, Drexel University, Philadelphia, PA, USA

[2]Department of Epidemiology and Biostatistics, Dornsife School of Public Health, Drexel University, Philadelphia, PA, USA

[3]Department of Epidemiology, School of Public Health, University of Alabama at Birmingham, Birmingham, AL, USA

[4]Department of Biostatistics, School of Public Health, University of Alabama at Birmingham, Birmingham, AL, USA

[5]Graduate School of Medical Sciences, Weill Cornell Medicine, Cornell University, New York, NY, USA

Correspondence

Tran B. Huynh, PhD, CIH, Department of Environmental and Occupational Health, Dornsife School of Public Health, Drexel University, 3215 Market St, Nesbitt Hall R613, Philadelphia, PA 19004, USA.
Email: tbh38@drexel.edu

Funding information

National Institute of Aging; National Institute of Neurological Disorders; National Institute for Occupational Safety and Health

Abstract

Background: The work environment can contribute to the risk of cardiovascular diseases (CVD) including stroke. Our objective was to identify occupations with elevated risk of stroke within the Reasons for Geographic and Racial Differences in Stroke (REGARDS) cohort.

Methods: We analyzed incident stroke outcomes (ischemic and hemorrhagic strokes) from 2003 to 2020 and employment characteristics of 13,659 adults aged ≥45 years enrolled in a national population-based cohort study. Using a modified Poisson regression approach, we estimated the relative risks (RRs) and the associated 95% confidence intervals (CI) of stroke in relation to years of employment within each occupation coded using the US Census two-digit Standard Occupation Code. Models were adjusted for Framingham Stroke Risk Score, region, race, age, and body mass index. We conducted stratified analysis by sex, employment time period (pre-1975 vs. post-1975), and region.

Results: Workers in the following occupations had a greater risk of stroke with longer duration of employment (per decade): protective service (RR: 2.35, 95% CI: 1.11, 4.97), food preparation and service (RR: 1.51, 95% CI: 1.05, 2.19), and transportation and material moving (RR: 1.30, 95% CI: 1.00, 1.69). The stroke risk in these occupations was disproportionately elevated in men, and differed by region and employment time period.

Conclusions: Longer employment in protective service, food preparation and serving, and transportation and materials moving occupations may increase the risk of stroke. Surveillance may uncover specific work-related risk factors in these occupations, leading to interventions to reduce the burden of stroke among US workers.

KEYWORDS

employment duration, occupations, sex differences, stroke, stroke belt

© 2022 Wiley Periodicals LLC.

1 | INTRODUCTION

Cardiovascular diseases (CVD) (coronary heart diseases, heart failure, stroke, and hypertension) affect approximately 50% of American adults (126.9 million in 2018).[1] The combined annual direct cost of managing these illnesses (e.g., hospitals, physicians) and indirect cost of lost productivity were approximately $363.4 billion in the United States.[1] Stroke, the fifth leading cause of death, affects approximately 3% of adults (7.6 million)[1] and stroke survivors may experience a wide range of disabilities that could affect their quality of life and ability to continue to work.

The work environment may introduce a variety of stressors that can adversely affect cardiovascular health. They include job strain,[2,3] job loss and unemployment,[4] long work hours,[5–7] rotating night shift work,[8] occupational stress,[9,10] shift work,[2,11] effort-reward imbalance,[12,13] and chemicals such as arsenic, benzopyrenes, lead, dynamite, carbon disulfide, carbon monoxide, metalworking fluids, and electrolytic aluminum production or production of paper where sulfate is used,[14] pesticides,[15] and noise.[16] Certain occupations and their associated characteristics may specifically increase the risk of stroke either directly or indirectly by influencing lifestyle factors such as physical activity, psychological stress, and diet. The primary aim of our investigation was to identify occupations at high risk of stroke within the Reasons for Geographic and Racial Differences in Stroke (REGARDS) cohort. Second, we explored whether there were differences by sex, region, and employment time period in the association between occupation and stroke.

2 | METHODS

2.1 | Data source

The REGARDS study is a prospective national population cohort of 30,239 Black and White adults aged 45 years or older designed to investigate the risk factors and racial disparities in stroke.[17] During baseline data collection (between 2003 and 2007), participants were recruited to complete a telephone interview, followed by an in-home physical exam. Participants are followed every 6 months by phone to ask about their health, including ascertaining stroke outcomes. Participants from the stroke belt and buckle region (areas in the Southeastern region of the United States that include North Carolina, South Carolina, Georgia, Tennessee, Alabama, Mississippi, Arkansas, and Louisiana) known to have elevated stroke mortality were oversampled.[18] The study design is described in detail elsewhere.[17]

Between 2011 and 2013, active REGARDS participants were invited to complete an occupational survey by telephone interview lasting on average 10 min.[19] The survey collected baseline (2003–2007) and current (2011–2013) employment status and narrative occupation data for up to three jobs (current job, baseline job, and longest-held job) to capture each participant's work history. Using a computer assistant coding system, narrative occupational data were coded to detailed four-digit Census 2002 occupation codes. Census occupation codes were subsequently translated into two-digit Standard Occupation Codes for analysis using a standard cross-walk process.[19] A total of 17,333 participants provided information on the occupation. Details of the occupational survey and occupation coding process can be found in MacDonald et al.[19]

2.2 | Outcome

Suspected stroke events were identified every 6 months via follow-up telephone interviews. Medical records of suspected strokes were adjudicated by physicians using the World Health Organization definition.[20,21] Ischemic and hemorrhagic strokes were combined as the outcome variable and reported strokes for which adjudication was complete between 2003 and April 2020 were included in the initial sample. The 89 individuals who had stroke before the start of employment were excluded.

2.3 | Exposure

Because a majority of participants reported a longest-held job, duration of employment in the longest-held job was used to investigate the effect of job tenure on stroke risk within each occupation. Job tenure (in years) was computed from participant reports of the year they started and ended employment in the longest-held job. If the participant was still employed in the longest-held job when the occupational survey was administered, year of occupational survey was coded as the end year of the longest-held job. We used the duration of employment in the longest-held job as a continuous variable in the main analysis.

2.4 | Covariates

Based on prior literature, biological sex is an effect modifier for occupational health risk of chronic work-related diseases because of the systematic differences in the distribution of labor, job tasks, employment patterns, societal roles, expectations, responsibilities as well as biological and psychological response to the hazards in the workplace.[22,23] While there has not been specific research on sex as an effect modifier specifically related to the occupational risk of stroke, it could be safely assumed that the same mechanisms apply. Potential confounding variables of interest were the Framingham Stroke Risk Score (FSRS) (continuous variable), region (stroke belt, nonstroke belt), race (Black, White), body mass index (BMI) (<25, $\geq 25\ kg/m^2$), education (less than high school, high school graduate, some college, college graduate and above), income (<$20,000, $20,000–$34,999, $35,000–$74,999, $75,000 and above, and refused), and marital status (married, not married). The FSRS is a standard clinical tool to predict stroke risk based on individual risk factors: age, sex assigned at birth, systolic blood pressure, use of antihypertensive medications, diabetes mellitus, smoking, atrial fibrillation, left ventricular hypertrophy, and prior coronary heart disease.[24,25]

2.5 | Analytic sample

Figure 1 shows the selection of the sample. We started with 17,333 participants for whom occupational information was collected. We restricted the sample to participants with the longest-held job that started before enrollment in the REGARDS baseline exam to eliminate the potential issue relating to the temporal sequence of exposure starting after stroke, which left 15,572. We verified that none of the participants had stroke before the baseline exam. We further excluded those with missing FSRS ($n = 1654$), missing data on education ($n = 1$), BMI ($n = 51$), those in the military ($n = 205$), and in occupations not codable ($n = 2$). The final sample included 13,659 persons.

2.6 | Statistical analysis

2.6.1 | Main analysis

We examined frequencies and percentages of demographic covariates overall and by stroke status and used χ^2 tests to determine association for categorical variables and *t*-test for continuous variables. For each occupation, we separately estimated the relative risks (RRs), and the associated 95% confidence intervals (CI), of stroke in relation to years of employment in the longest-held job as a continuous variable using the modified Poisson regression approach.[26,27] The modified Poisson regression is a suitable method for cohort study analysis and for ease of interpretation of risk estimates. Model 1 was unadjusted and Model 2 was adjusted for the FSRS, region, race, age, and BMI. We stratified analysis by the sex assigned at birth. FSRS accounts for age but, even at the risk of over-adjustment, we additionally adjusted for age since this variable may be related to occupational exposures and other unmeasured risk factors, not only risk of stroke.

2.6.2 | Sensitivity analyses

We estimated the association of being employed in each occupation compared to all occupations combined (dichotomous employed analysis) with the risk of stroke via modified Poisson regression (Supporting Information: SM Table 2) to compare which exposure metric (employed or duration of employment) is a better predictor of stroke. The term "employed" in our context refers to whether a participant was employed in an occupation for their longest-held job only. We also conducted analyses using the duration of employment as a categorical variable (<10, ≥10 years). Finally, we performed analyses for Model 3 that included covariates from Model 2 plus socioeconomic factors, namely education, income, and marital status with the understanding that income and education are highly correlated with occupation, and likely over-adjust the model.

2.6.3 | Exploratory analyses

We examined frequencies and percentages for a sample of participants with missing FSRS to compare the demographic differences between those missing FSRS and our sample (with FSRS). We additionally explored stroke risk by industry (which might be useful for surveillance purposes), employment status at the time of the occupational survey interview (active vs. inactive) to assess the potential impact of the healthy worker bias, region, and year when employment started (≤1975, >1975). While the year 1975 may be somewhat arbitrary, it was during this era that the Occupational Safety and Health Act was passed (1970), creating the Occupational Safety and Health Administration (OSHA) to enforce workplace

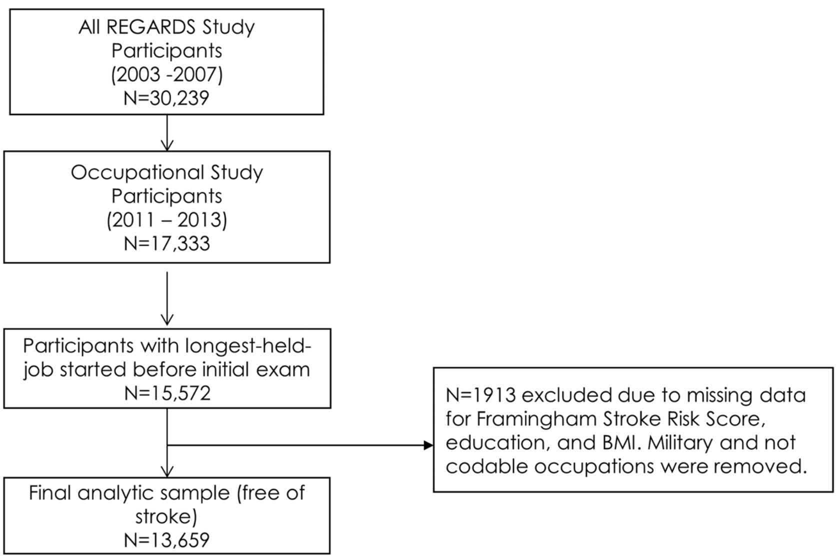

FIGURE 1 Selection of analytic sample

regulations, and the National Institute of Occupational Safety and Health (NIOSH) to conduct research and training in occupational health. While we do not assume working conditions drastically improved within this short period of time since the creation of the OSH Act, there is evidence that workplace exposures declined over time in many countries, including the United States.[28]

Data analyses were performed in R.[29]

The proposed research has been approved by the IRBs at all participating institutions.

3 | RESULTS

The characteristics of the sample are described in Table 1. Approximately 36% of the sample were Black participants, compared to the racial makeup of the parent study of 42% Black. The majority of the working participants were female (54%), over the age of 55 (86%), self-reported current smokers at baseline (52%), living outside of the stroke belt region (66%), had BMI ≥ 25 kg/m^2 (76%), had at least some college education (70%), and earned personal income greater than \$35,000 (56%). Participants with stroke were more likely to be male, 65+ years of age, lower income, smokers, less educated, have had higher FSRS, and be unmarried. The demographic characteristics among those with missing FSRS were mostly similar, except there was a higher proportion of Black participants, people with lower educational attainment, and not married (Supporting Information: SM Table 1). To adjust for the lifestyle risk factors of stroke in the statistical analysis, we selected cohort members on the availability of information required to compute FSRS. If missingness in FSRS is related to its value and occupational exposures, our results may present a distorted picture of the impact of such occupational exposures on stroke. Nonetheless, our findings remain internally valid even though they may not generalize to the whole of the REGARDS cohort.

3.1 | Main analysis

Table 2 presents frequencies, percentages, and the association of employment duration within each occupation in the longest-held job with the risk of stroke. A relatively large proportion of participants held jobs in management, education, training, library, office and administrative support, and production. The median FSRS appeared to be elevated among workers in occupations such as transportation and material moving, production, installation, maintenance and repair, construction and extraction, farming, fishing, forestry, building and grounds cleaning and maintenance, and architecture and engineering.

We report the association of employment duration within each occupation with the risk of stroke in Table 2 and Figure 2. For every 10 years of work in a protective service occupation, the risk of stroke more than doubled on average (RR: 2.35, 95% CI: 1.11, 4.97), although it must be noted that this particular analysis did not adjust for BMI because all 9 cases had BMI ≥ 25. A decade of work in food preparation and serving (RR: 1.51, 95% CI: 1.05, 2.19), or transportation and materials moving occupations (RR: 1.30, 95% CI: 1.00, 1.69) likewise appeared to confer an elevated risk of stroke, although adjusted association may be at borderline. Farming, fishing, and forestry group were associated with a reduced risk (RR: 0.30, 95% CI: 0.10, 0.87). These estimates were not materially affected by adjustment for confounders. Additional adjustments for socioeconomic factors, namely education, income, and marital status, produced similar results, but the estimates became less stable and therefore less reliable, likely due to the collinearity of social economic status history with working life (Supporting Information: SM Table 4).

Our stratified analysis by the sex assigned at birth for the duration of employment (continuous variable) indicated that the excess risks were largely distributed among men (Table 3). Men in protective service had, on average, more than twice the risk for every 10 years of service but the risk among women was not elevated (women: N = 63, RR: 0.94, 95% CI: 0.56, 1.60 vs. men: N = 190, RR: 2.78, 95% CI: 1.38, 5.62). It must be noted that in the analysis of women in protective service, the model was adjusted for FSRS and age only because all cases were White, in nonstroke belt region, and had BMI ≥ 25. For the men in protective service, all cases had BMI ≥ 25. Interestingly, for transportation and materials moving occupations, lower risk of stroke was observed among women (N = 117, RR: 0.14, 95% CI: 0.04, 0.48), whereas men had a 38% higher risk for every 10 years of service (N = 423, RR: 1.38, 95% CI: 1.06, 1.80). Men in food preparation and serving had a higher risk (N = 5, RR: 15.46, 95% CI: 3.67, 65.04) compared to women (N = 177, 1.05: 95% CI: 0.66, 1.66). We are less confident about the risk estimate in the men employed in food preparation and serving because of the small sample and all five cases were not in stroke belt region and had BMI ≥ 25.

3.2 | Sensitivity analyses

Supporting Information: SM Table 2 reports the estimated RRs of stroke associated with employment duration analyzed as a categorical variable (<10 vs. ≥10 years) for each occupation. After adjustment, lower risks were associated with being employed in legal occupation (RR: 0.17, 95% CI: 0.03, 0.88) and building and grounds cleaning and maintenance (RR: 0.27, 95% CI: 0.09, 0.82). Interestingly, all stroke cases in the protective service group worked less than 10 years. While not statistically significant, risks appeared to be on average elevated in several blue-collar occupations and lower risks may be present among white-collar jobs (except management). The elevated risk with longer tenure in food preparation and serving as well as transportation and materials moving were consistent with those reported in Table 2, albeit less precise. However, the previously observed association with farming (Table 2) was reversed, implying higher, not lower, risk with longer tenure in the fully adjusted model, thereby suggesting that the association is greatly influenced by confounders and the functional form of the employment duration variable.

TABLE 1 Characteristics of REGARDS participants in this study by stroke status

	Stroke (N, %)			
	No (N = 12919)	Yes (N = 740)	Total (N = 13659)	p Value[a]
Sex assigned at birth				<0.001
Female	7054 (55)	355 (48)	7409 (54)	
Male	5865 (45)	385 (52)	6250 (46)	
Race				0.43
Black	4580 (35)	273 (37)	4853 (36)	
White	8339 (65)	467 (63)	8806 (64)	
Age				<0.001
45–54	1848 (14)	37 (5)	1885 (14)	
55–64	5654 (44)	244 (33)	5898 (43)	
65+	5417 (42)	459 (62)	5876 (43)	
Income				<0.001
<$20,000	1442 (11)	109 (15)	1551 (11)	
$20,000–$34,999	2837 (22)	213 (29)	3050 (22)	
$35,000–$74,999	4552 (35)	244 (33)	4796 (35)	
$75,000 and above	2798 (22)	88 (12)	2886 (21)	
Refused	1290 (10)	86 (12)	1376 (10)	
Smoking[b]				<0.001
Yes	6641 (51)	429 (58)	7070 (52)	
No	6278 (49)	311 (42)	6589 (48)	
Region[c]				0.24
Stroke belt	4353 (34)	265 (36)	4618 (34)	
Nonstroke belt	8566 (66)	475 (64)	9041 (66)	
BMI				0.08
BMI < 25 kg/m^2	3158 (24)	160 (22)	3318 (24)	
BMI ≥ 25 kg/m^2	9761 (76)	580 (78)	10341 (76)	
Framingham Stroke Risk Score				<0.001
Mean (SD)	7.85 (7.96)	11.91 (9.58)	8.07 (8.09)	
Range	0.45–86.02	1.02–68.27	0.45–86.02	
Education				<0.001
Less than high school	875 (7)	62 (8)	937 (7)	
High school graduate	2942 (23)	226 (31)	3168 (23)	
Some college	3477 (27)	198 (27)	3675 (27)	
College graduate and above	5625 (44)	254 (34)	5879 (43)	
Marital status				0.02
Married	8395 (65)	449 (61)	8844 (65)	
Not married	4524 (35)	291 (39)	4815 (35)	

Abbreviations: BMI, body mass index; REGARDS, Reasons for Geographic and Racial Differences in Stroke; SD, standard deviation.

[a]*p* Values obtained by χ^2 test for categorical variables and *t*-test for continuous variables.

[b]Self-reported as current smoker at baseline.

[c]Stroke belt region includes North Carolina, South Carolina, Georgia, Tennessee, Alabama, Mississippi, Arkansas, and Louisiana. Nonstroke belt region includes the remaining 40 contiguous US States and the District of Columbia.

TABLE 2 Estimated relative risk of stroke associated with duration of employment per 10 years within each occupation; each occupation analyzed separately

	Stroke			Model 1		Model 2	
Occupation groups	No (*N* = 12919)	Yes (*N* = 740)	Framingham Stroke Risk Score [median (IQR)]	RR (95% CI)	*p* Value	RR (95% CI)	*p* Value
11:Management	1913 (149)	100 (14)	5.61 (6.70)	1.13 (0.96, 1.33)	0.13	1.02 (0.87, 1.19)	0.82
13:Business and financial operations	552 (4)	22 (3)	4.69 (6.15)	0.95 (0.63, 1.41)	0.79	0.84 (0.55, 1.27)	0.41
15:Computer and mathematical science	205 (2)	10 (1)	5.13 (5.90)	1.06 (0.55, 2.04)	0.85	0.91 (0.53, 1.59)	0.75
17:Architecture and engineering	388 (3)	23 (3)	6.39 (6.86)	0.80 (0.54, 1.20)	0.28	0.78 (0.51, 1.19)	0.25
19:Life, physical, and social science	211 (2)	8 (1)	4.89 (6.15)	1.00 (0.50, 2.01)	1.00	0.91 (0.47, 1.75)	0.78
21:Community and social services	416 (3)	22 (3)	4.97 (6.05)	0.90 (0.63, 1.29)	0.55	0.87 (0.62, 1.24)	0.45
23:Legal	140 (1)	7 (1)	5.42 (6.64)	0.91 (0.49, 1.72)	0.78	0.67 (0.33, 1.37)	0.28
25:Education, training, and library	1625 (13)	74 (10)	4.75 (5.95)	0.97 (0.80, 1.18)	0.75	0.89 (0.73, 1.10)	0.28
27:Arts, design, entertainment, sports, and media	221 (2)	5 (1)	4.66 (5.91)	1.03 (0.51, 2.07)	0.93	1.05 (0.054, 2.09)[a]	0.86
29:Healthcare practitioners and technical	853 (7)	44 (6)	4.51 (6.99)	1.04 (0.80, 1.36)	0.76	0.99 (0.76, 1.29)	0.93
31:Healthcare support	243 (2)	16 (2)	5.61 (8.02)	0.92 (0.58, 1.48)	0.74	0.80 (0.50, 1.28)	0.35
33:Protective service (firefighters/law enforcement)	244 (2)	9 (1)	5.97 (6.72)	2.84 (1.21, 6.66)	0.02	2.35 (1.11, 4.97)[b]	0.04
35:Food preparation and serving related	218 (2)	19 (3)	5.69 (7.25)	1.61 (1.09, 2.38)	0.02	1.51 (1.05, 2.19)	0.03
37:Building and grounds cleaning and maintenance	236 (2)	14 (2)	6.80 (9.22)	0.75 (0.38, 1.51)	0.42	0.65 (0.30, 1.41)	0.28
39:Personal care and service	256 (2)	16 (2)	5.17 (7.75)	1.08 (0.70, 1.65)	0.73	0.96 (0.66, 1.41)	0.85
41:Sales and related	870 (7)	69 (9)	5.71 (6.61)	1.14 (0.95, 1.38)	0.17	1.07 (0.90, 1.28)	0.45
43:Office and administrative support	1950 (15)	110 (15)	4.97 (6.62)	1.10 (0.93, 1.31)	0.28	1.07 (0.91, 1.27)	0.41
45:Farming, fishing, and forestry	40 (0)	4 (0)	6.47 (5.98)	0.36 (0.12, 1.10)	0.07	0.30 (0.10, 0.87)	0.03
47:Construction and extraction	351 (3)	25 (3)	7.71 (7.43)	1.00 (0.74, 1.34)	1.00	0.95 (0.70, 1.30)	0.77
49:Installation, maintenance, and repair	421 (3)	29 (4)	6.78 (6.64)	0.98 (0.72, 1.34)	0.90	0.91 (0.66, 1.24)	0.54
51:Production	1058 (8)	80 (11)	6.61 (7.89)	1.20 (0.98, 1.46)	0.07	1.16 (0.95, 1.43)	0.14
53:Transportation and material moving	508 (4)	34 (5)	7.07 (7.42)	1.42 (1.09, 1.85)	0.01	1.30 (1.00, 1.69)	0.05

Note: Model 1 = RR and 95% CI from modified Poisson regression models with duration of employment analyzed as a continuous variable without adjustment. Model 2 = Modified Poisson regression models, adjusted for Framingham Stroke Risk Score, region, race, age, and BMI. Sixty participants missing employment duration data were excluded from the analysis.

Abbreviations: BMI, body mass index; CI, confidence intervals; IQR, interquartile range; RR, relative risk.

[a]Model adjusted for Framingham Stroke Risk Score and race (all five cases were White, in nonstroke belt region, and had BMI ≥ 25).

[b]Model adjusted for Framingham Stroke Risk Score, region, race, and age (all nine cases had BMI ≥ 25).

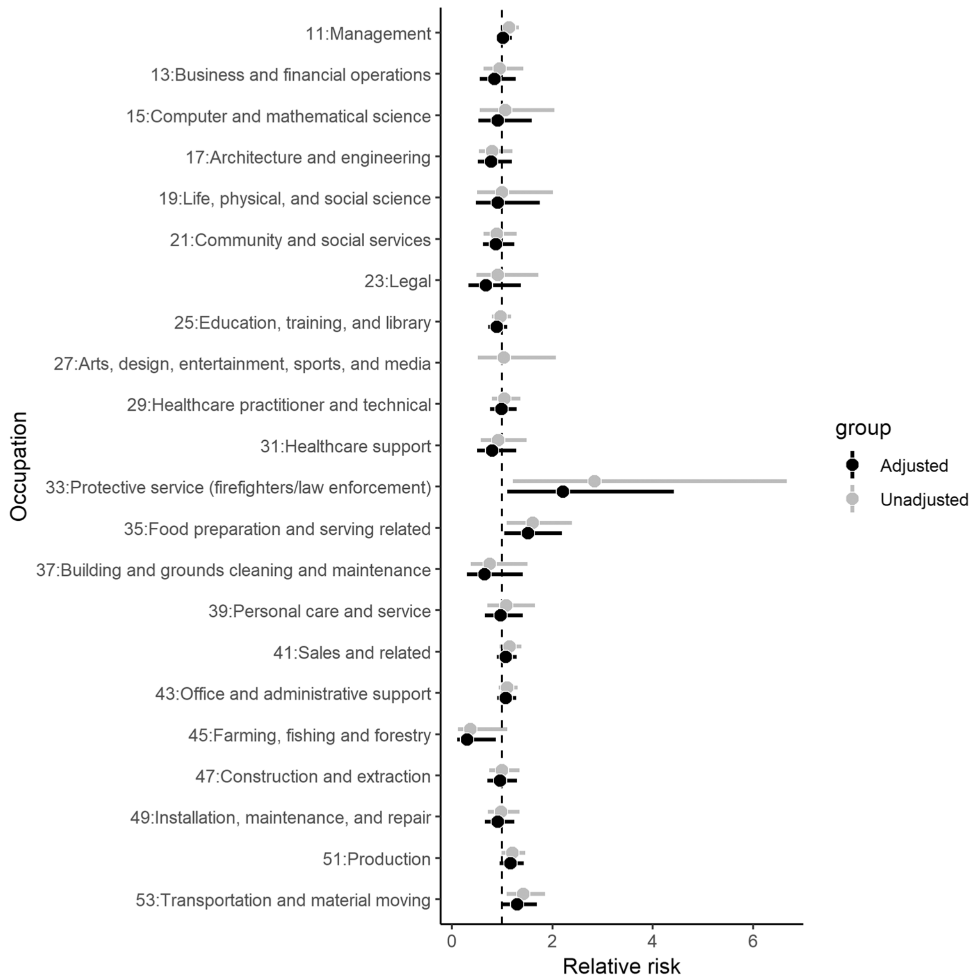

FIGURE 2 Estimated relative risk of stroke and 95% confidence intervals in relation to the duration of employment per 10 years within each occupation (see details in Table 2); Unadjusted models used duration of employment analyzed as a continuous variable; adjusted models included the Framingham Stroke Risk Score, region (stroke belt vs. nonstroke belt), race, age, and BMI (<25 vs. ≥25 kg/m^2).

Supporting Information: SM Table 3 presents the estimated RRs of stroke among participants being employed in an occupation for their longest-held job. The unadjusted analysis revealed elevated risks of stroke in food preparation and serving, sales, production, farming and fishing, and forestry, but the association for the sales group was stronger after adjustment for FSRS, region, race, and BMI (RR: 1.35, 95% CI: 1.08, 7.74). Education, training, and library occupations appear to be associated with a reduced risk of stroke after similar adjustments (RR: 0.78, 95% CI: 0.62, 0.99).

3.3 | Exploratory analyses

We explored risk by industry in Supporting Information: SM Table 5. Elevated risk was observed in mining, but all cases were White and in stroke belt region; and reduced risk in wholesale trade where all cases were in the stroke belt region. Analyses restricted to participants no longer employed at the time of the occupational study interview (Supporting Information: SM Table 6) showed a pattern of elevated stroke risk similar to the main analyses reported in Table 3 (protective service, food preparation, and serving, but not transportation and materials moving), suggesting little evidence that healthy worker effect bias materially affected results for the protective service and food preparation groups; however, results for the transportation and materials moving and production differed and, therefore, may be impacted by healthy worker effect bias; reduced risk in farming fishing and forestry was observed among inactive employees.

Stratified analysis by region (Supporting Information: SM Table 7) revealed that the risk among protective service and production was higher for those who reside in the stroke belt region compared to the nonstroke belt region. Conversely, stroke risk for workers in food preparation and serving occupations was greater for those not living in the stroke belt compared to the stroke belt region. Finally, we examined the effect of the year when employment began (Supporting Information: SM Table 8) and found that for some occupations, the start year was associated with stroke risk. For instance, after allowing for confounders that included age, stroke risks for participants who worked in production, food preparation, or personal care services were elevated only if they began working before 1975. Risk for participants in transportation and materials moving and protective services increased only after 1975.

4 | DISCUSSION

In our study, we compared various exposure metrics to identify occupations with the highest risk of stroke and found that employment duration analyzed as a continuous variable may be a more robust and reliable metric compared to the dichotomous "employed" and the categorical employment duration metrics. A key finding of this study is that the risk of stroke among workers in protective service, food preparation and serving, and transportation and materials moving occupations increased with longer duration of employment after adjusting for the FSRS, region, race, age, and BMI.

Protective service includes jobs such as correctional officers, firefighters, police officers, and security guards.[30] Congruent with prior studies, there is substantial evidence that firefighters are at increased risk of CVD including stroke.[31,32] Firefighters are known to work long hours[33] and in shifts[5,34] and shift work have been linked to stroke.[8] Similarly, firefighters are also exposed to intense particulate matter during fire suppression events and long-term exposure to fine particles in ambient air is associated with an increased risk of stroke in the general population.[35] All participants in the protective service group had high BMI, suggesting that the work environment and lifestyle factors may have some additive effects on stroke risk. For instance, in a study of male California firefighters, Choi et al.,[36] concluded that 24-h work shifts and sedentary work substantially increased risk of obesity in male firefighters.

Consistent with our observation of excess risk of stroke in transportation-related occupations, Sieber et al.[37] conducted a national survey of long-haul truck drivers and reported that truck drivers had high prevalence of obesity (69% vs. 31% in the US adult working population), smoking (51% vs. 19% in the working population), diabetes, and hypertension. These lifestyle risk factors (smoking and obesity) and clinical conditions (diabetes and hypertension) are known to be strongly associated with stroke[1,38] but we accounted for these confounders in our analyses, implying that there may be occupation-specific risks that these lifestyle factors do not explain. In addition, truck drivers tend to have irregular schedules, long hours, and limited access to healthy food while traveling which makes it difficult for them to lead a healthy lifestyle and puts them at greater risk of stroke.

While there is limited literature on food preparation and serving workers and stroke, our study found an elevated risk of stroke in this occupation. The National Health Interview Survey (NHIS) from 2008 to 2012 found that persons in service and blue-collar occupations were more likely to report a history of coronary heart disease or stroke than those in white-collar occupations.[39] Additionally, two industry groups with elevated prevalence ratios for stroke were Administrative and Support Waste Management and Remediation Services and Accommodation and Food Service.[39] One plausible explanation is that workers in food services industries are more likely to work alternative shifts,[40] which is a potential risk factor for stroke. Another possible explanation is exposure to fine particulates and polycyclic aromatic hydrocarbons (PAHs) emitted in the cooking process. The presence of PAHs in commercial kitchens has been reported in multiple studies.[41,42] While there is no study investigating exposure to PAH and stroke specifically for food workers, there is early evidence of an association between PAH exposure and ischaemic heart disease among asphalt workers[42] and PAH exposure and stroke in the general population in the US.[44]

We observed that farming, fishing, and forestry were inversely related to risk of stroke, but this could be due to a healthy worker survivor effect. Additionally, this occupation also had the smallest sample size so our level of confidence in the effect estimates is low. Due to the physically strenuous working conditions for these occupations, those who remained in these occupations longer than 10 years must be fit enough to be able to continue these jobs, which entails having lower risk of lifestyle factors related to stroke. Stratification by active works status at the time of the interview is not guaranteed to control for this form of bias and did not weaken the evidence for the apparent protective effect in this occupation.

Our dichotomous "employed" analysis results were not consistent with the duration of employment analysis, illustrating that different exposure metrics can yield different results. We suspect that latent confounding due to differences in lifestyle risk factors between occupations may be more prominent in analyses that compare across occupations as opposed to this that perform within-occupation comparisons utilizing duration of employment exposure metrics. There was a notable variation in FSRS among occupations (Table 2), which supports the possibility of residual confounding in our between-occupation risk comparisons.

Our results were consistent with the results of a previous study[45] examining risk factors among 7532 REGARDS participants who reported to have had a job at enrollment. They reported that sales and lower-status office workers tended to have a lower prevalence of optimal cardiovascular health, measured by the American Heart Association's Life's Simple 7 composite score in the domains of smoking, diet, physical activity, BMI, blood pressure, total cholesterol, and fasting glucose.[45,46] Workers in protective services and food preparation and serving occupations had a lower prevalence of optimal clinical health (fasting blood glucose, total cholesterol, and blood pressure).[45] While the outcomes they examined were mostly related to lifestyle risk factors, which we treated as confounders, our results imply the effects of the occupational factors on stroke risk through another pathway, not mediated by established clinical markers of increased risk of stroke. We presented results from both unadjusted and adjusted models which showed that adjustment of lifestyle risk factors tended to attenuate the effects but did not substantially change our main conclusion.

Evidence of differences in occupational risk by sex is important because the same occupation may entail tasks and risks that systematically differ by sex, a matter that deserves a close inspection

TABLE 3 Estimated relative risk of stroke associated with duration of employment per 10 years analyzed as a continuous variable within each occupation, stratified by sex assigned at birth.

	Females						Males					
	Stroke		Model 1				Stroke		Model 1			
Occupation groups	No	Yes	RR (95% CI)	*p* Value	Model 2	*p* Value	No	Yes	RR (95% CI)	*p* Value	Model 2	*p* Value
11:Management	702	29	1.30 (0.89, 1.90)	0.17	1.03 (0.76, 1.38)	0.87	1205	71	1.05 (0.88, 1.27)	0.57	0.99 (0.83, 1.19)	0.93
13:Business and financial operations	320	11	0.72 (0.37, 1.41)	0.33	0.68 (0.32, 1.44)	0.32	232	10	1.15 (0.75, 1.76)	0.52	1.02 (0.62, 1.66)	0.95
15:Computer and mathematical science	74	5	0.92 (0.32, 2.63)	0.88	0.98 (0.50, 1.93)	0.96	130	5	1.33 (0.65, 2.74)	0.44	1.19 (0.65, 2.19)	0.57
17:Architecture and engineering	45	0	No cases/cannot estimate risk				342	23	0.75 (0.50, 1.12)	0.16	0.72 (0.47, 1.09)	0.12
19:Life, physical, and social science	78	3	0.91 (0.20, 4.06)	0.90	0.90 (0.24, 3.45)[a]	0.88	132	5	1.05 (0.49, 2.24)	0.90	0.89 (0.42, 1.88)	0.76
21:Community and social services	212	14	0.56 (0.35, 0.92)	0.02	0.57 (0.32, 1.02)	0.06	202	8	1.41 (1.00, 1.98)	0.05	1.25 (0.95, 1.65)	0.11
23:Legal	60	2	0.71 (0.12, 4.39)	0.72	0.60 (0.13, 2.71)[b]	0.51	78	5	0.89 (0.44, 1.78)	0.74	0.78 (0.36, 1.69)	0.53
25:Education, training, and library	1180	50	0.96 (0.76, 1.23)	0.77	0.85 (0.66, 1.10)	0.22	441	24	0.92 (0.65, 1.30)	0.63	0.90 (0.63, 1.28)	0.55
27:Arts, design, entertainment, sports, and media	110	2	2.00 (0.74, 5.43)	0.17	2.33 (0.76, 7.14)[c]	0.14	111	3	0.61 (0.24, 1.58)	0.31	0.60 (0.23, 1.57)[c]	0.30
29:Healthcare practitioner and technical	704	34	1.00 (0.72, 1.39)	0.98	0.97 (0.71, 1.33)	0.86	145	10	1.04 (0.64, 1.70)	0.87	1.11 (0.59, 2.08)	0.74
31:Healthcare support	218	13	1.00 (0.61, 1.65)	0.99	0.89 (0.55, 1.42)	0.62	20	3	0.49 (0.10, 2.46)	0.38	0.23 (0.03, 2.06)[a]	0.19
33:Protective service (firefighters/ law enforcement)	62	1	0.91 (0.65, 1.29)	0.61	0.94 (0.56, 1.60)[c]	0.83	182	8	3.10 (1.27, 7.58)	0.01	2.78 (1.38, 5.62)[d]	0.004
35:Food preparation and serving related	177	14	1.02 (0.65, 1.60)	0.93	1.05 (0.66, 1.66)	0.85	39	5	8.08 (3.12, 20.88)	<0.001	15.46 (3.67, 65.04)[f]	<0.001
37:Building and grounds cleaning and maintenance	161	9	0.53 (0.27, 1.03)	0.06	0.43 (0.21, 0.90)[d]	0.03	75	4	1.44 (0.39, 5.38)	0.58	1.52 (0.57, 4.10)	0.41
39:Personal care and service	233	14	1.02 (0.62, 1.66)	0.95	0.90 (0.59, 1.35)	0.60	23	2	1.50 (0.74, 3.06)	0.26	1.69 (0.56, 5.12)[f]	0.35
41:Sales and related	441	25	1.20 (0.84, 1.70)	0.32	1.17 (0.83, 1.65)	0.37	424	44	1.02 (0.80, 1.31)	0.86	0.97 (0.76, 1.23)	0.81
43:Office and administrative support	1547	82	1.04 (0.85, 1.28)	0.69	1.01 (0.82, 1.24)	0.92	396	27	1.20 (0.86, 1.69)	0.28	1.09 (0.77, 1.54)	0.63
45:Farming, fishing and forestry	10	2	0.23 (0.04, 1.23)	0.09	0.12 (0.04, 0.43)[d]	0.001	30	2	0.50 (0.16, 1.53)	0.22	056 (0.34, 0.92)[g]	0.02
47:Construction and extraction	24	1	0.32 (0.16, 0.65)	0.002	0.03 (0.003, 0.34)[e]	0.004	322	23	1.02 (0.75, 1.37)	0.92	0.98 (0.72, 1.33)	0.88
49:Installation, maintenance, and repair	39	1	0.57 (0.39, 0.85)	0.01	0.56 (0.37, 0.85)[c]	0.006	380	27	0.98 (0.72, 1.35)	0.92	0.91 (0.66, 1.24)	0.54

TABLE 3 (Continued)

Occupation groups	Females						Males					
	Stroke		Model 1				Stroke		Model 1			
	No	Yes	RR (95% CI)	*p* Value	Model 2	*p* Value	No	Yes	RR (95% CI)	*p* Value	Model 2	*p* Value
51:Production	503	37	1.18 (0.87, 1.59)	0.29	1.16 (0.86, 1.55)	0.32	549	43	1.24 (0.93, 1.66)	0.14	1.18 (0.87, 1.62)	0.29
53:Transportation and material moving	113	4	0.60 (0.33, 1.10)	0.10	0.14 (0.04, 0.48)	0.002	394	29	1.48 (1.14, 1.93)	0.004	1.38 (1.06, 1.80)	0.02

Note: Model 1 = RR and 95% CI from modified Poisson regression models with duration of employment analyzed as a continuous variable without adjustment. Model 2 = Modified Poisson regression models, adjusted for Framingham Stroke Risk Score, region, race, age, and BMI. Sixty participants missing employment duration data were excluded from the analysis.

Abbreviations: BMI, body mass index; CI, confidence intervals; RR, relative risk.

[a]Model adjusted for Framingham Stroke Risk Score, race, age, and BMI (all cases were in nonstroke belt region).

[b]Model adjusted for Framingham Stroke Risk Score, region, age (all cases were Black, and had BMI ≥ 25).

[c]Model adjusted for Framingham Stroke Risk Score, age (all cases were White, in nonstroke belt region, and had BMI ≥ 25).

[d]Model adjusted for Framingham Stroke Risk Score, race, age, and region (all cases had BMI ≥ 25).

[e]Model adjusted for age only (all cases were White, in nonstroke belt region, and had BMI ≥ 25).

[f]Model adjusted for Framingham Stroke Risk Score, age, and race (all cases were in nonstroke belt region and had BMI ≥ 25).

[g]Model adjusted for race and region (all cases had BMI ≥ 25, very high age years at 72 and 74).

in any future delineation of causal factors. Evidence of effect modification by the time period when person worked may contain clues to temporal changes in the prevalence of work-related risk factors, as well as secular trends in confounders. Observed regional differences by occupation and stroke risk may be important for future occupational surveillance and interventions in the stroke belt region of the United States.

The results from this study may have several public health implications. First, the identification of clustering of stroke risk in occupations may help target interventions. While descriptive population-based epidemiological analysis at the occupation level can be broad, it could help narrow down places of work for intervention because many worksites have been successfully used as places for health promotion to prevent chronic diseases (e.g., heart disease, stroke, and cancer).[47,48] For example, workplace stress reduction programs aiming at reducing psychosocial stressors (e.g., high psychological demands, low decision latitude, low social support, and low reward) have been shown to produce clinically significant reduction in blood pressure[49] and incidence of mental health problems.[50] Systematic reviews of workplace interventions suggested that organizational changes are beneficial to both worker well-being and the organizations.[51,52] Our findings could help to prioritize research, health protection, and promotion agenda in these high-risk occupations. Second, our study may stimulate surveillance of work-related hazards and CVD outcomes including stroke in high-risk occupations. Finally, the results should inspire future research investigating exposures that are common across high-risk occupations and industry. There is a need to better understand how the work environment within each high-risk occupation affects stroke risk, so that policy can address specific exposures within the workplaces.

4.1 | Strengths and limitations

4.1.1 | Our study has several limitations

First, we only focused on participants with reported longest-held jobs, not their entire occupational history. Our sample within the REGARDS cohort is likely biased toward self-employed individuals as reported by Macdonald et al.[53] Second, in the within-occupation analysis, some occupations had small sample sizes which limit our level of confidence in their estimates. The small sample sizes also prevented us to perform the adjustment in some occupation groups which we noted in the footnotes and impact the interpretation of the results in those groups. Third, exposures were crudely assumed to be shared by members of the same group (e.g., occupation or industry), as is common in general population surveys of occupational risks. Consequently, our work suffers from concerns about bias from the misclassification of causal exposures. However, based on occupations, industry, and years of employment, it may be possible to assess exposures that are common across at-risk occupations to further elucidate the specific occupational risks of stroke that may be present in the cohort. Fourth, there is a potential for survival bias in which those who were healthier might be more likely to enroll in the occupational survey, and such selection may in theory be related to work-related exposures that caused poor health (including stroke). We suspect that such selection would tend to have attenuated associations that we report. Finally, we acknowledge that a large number of estimated effects may have led to spurious associations if judged based on *p* value alone (null hypothesis testing). We reported all tested associations, not the ones that had *p* value < 0.05 to mitigate this matter.

4.1.2 | Our study has several strengths

The use of a large national population-based cohort allows us to examine multiple occupations at the same time and regional differences that could potentially have implications for more targeted region-specific interventions and surveillance. Additionally, we had reliable stroke outcomes through central adjudication and job information from participants, so the risk of bias from disease misclassification is minimal.

5 | CONCLUSIONS

This study utilized a large population-based cohort of older adults from the REGARDS study to identify occupations at greater risk of stroke. Our within-occupation analysis using duration of employment identified workers in protective service, food services, and transportation and materials moving occupations as having greater risk of stroke as they remain longer in the job. The stroke risks in those aforementioned occupations were largely driven by men, suggesting that risk factors for men and women within those occupations may be different. Further research to elucidate these sex- or gender-specific risk factors would help to tailor future interventions. Associations that persist in post-1975 era, such as transportation and material moving, may deserve to be given priority because they are more likely to still entail specific exposures that require control to lower the risk of stroke.

AUTHOR CONTRIBUTIONS

Tran B. Huynh led the design of the study, preparation of the manuscript proposal, analysis, and interpretation of the data as well as drafting of the manuscript. Igor Burstyn co-led the study design, preparation of the manuscript proposal, interpretation of the data, and was involved in drafting the manuscript. Leslie A. McClure facilitated data transfer data acquisition, and was involved in the manuscript proposal preparation, analysis and interpretation of the data, and manuscript preparation. Virginia J. Howard, Suzanne E. Judd, and Monika M. Stafford were involved in the manuscript proposal, analysis and interpretation of the data, and provided input to the revision of the manuscript drafts. All authors approved the final manuscript and agreed to be accountable for all aspects of the study.

ACKNOWLEDGMENTS

We are grateful for Dr. Leslie A. McDonald's tremendous help with understanding the occupational ancillary data and her guidance on the analysis. We thank the investigators, staff, and participants of the REGARDS study for their valuable contributions. A full list of participating investigators and institutions can be found at https://www.uab.edu/soph/regardsstudy/. Dr. Huynh was supported by the K01OH011191 from the National Institute for Occupational Safety and Health (NIOSH) during the early analysis of the data. REGARDS is supported by cooperative agreement U01 NS041588 co-funded by the National Institute of Neurological Disorders and Stroke (NINDS) and the National Institute on Aging (NIA), National Institutes of Health. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NINDS or the NIA. Representatives of the NINDS were involved in the review of the manuscript but were not directly involved in the collection, management, analysis or interpretation of the data. The occupational ancillary study was supported by intramural funding from the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention. Representatives from NIOSH did not have any role in the design and conduct of the study, the collection, management, analysis, and interpretation of the data, or the preparation or approval of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

DISCLOSURE BY AJIM EDITOR OF RECORD

John Meyer declares that he has no conflict of interest in the review and publication decision for this article.

DATA ACCESSIBILITY

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ETHICS APPROVAL AND INFORMED CONSENT

The proposed research has been approved by the IRBs at all participating institutions (Drexel University, University of Alabama-Birmingham, and Weill Cornell Medical College). This research study used deidentified data only.

ORCID

Tran B. Huynh http://orcid.org/0000-0002-1542-8582
Virginia J. Howard http://orcid.org/0000-0003-4912-9975

REFERENCES

1. Virani SS, Alonso A, Aparicio HJ, et al. Heart disease and stroke Statistics—2021 update: a report from the American Heart Association. *Circulation*. 2021;143(8):e254-e743. doi:10.1161/CIR.0000000000000950
2. Moretti Anfossi C, Ahumada Muñoz M, Tobar Fredes C, et al. Work exposures and development of cardiovascular diseases: a systematic review. *Ann Work Expo Health*. 2022;66:698-713. doi:10.1093/annweh/wxac004

3. Kivimäki M, Kawachi I. Work stress as a risk factor for cardiovascular disease. *Curr Cardiol Rep*. 2015;17(9):74. doi:10.1007/s11886-015-0630-8
4. Eshak ES, Honjo K, Iso H, et al. Changes in the employment status and risk of stroke and stroke types. *Stroke*. 2017;48(5):1176-1182. doi:10.1161/STROKEAHA.117.016967
5. Kivimäki M, Jokela M, Nyberg ST, et al. Long working hours and risk of coronary heart disease and stroke: a systematic review and meta-analysis of published and unpublished data for 603 838 individuals. *Lancet*. 2015;386(10005):1739-1746. doi:10.1016/S0140-6736(15)60295-1
6. Descatha A, Sembajwe G, Pega F, et al. The effect of exposure to long working hours on stroke: a systematic review and meta-analysis from the WHO/ILO joint estimates of the work-related burden of disease and injury. *Environ Int*. 2020;142:105746. doi:10.1016/j.envint.2020.105746
7. Li J, Pega F, Ujita Y, et al. The effect of exposure to long working hours on ischaemic heart disease: a systematic review and meta-analysis from the WHO/ILO joint estimates of the work-related burden of disease and injury. *Environ Int*. 2020;142:105739. doi:10.1016/j.envint.2020.105739
8. Brown DL, Feskanich D, Sanchez BN, Rexrode KM, Schernhammer ES, Lisabeth LD. Rotating night shift work and the risk of ischemic stroke. *Am J Epidemiol*. 2009;169(11):1370-1377. doi:10.1093/aje/kwp056
9. Tsutsumi A, Kayaba K, Kario K, Ishikawa S. Prospective study on occupational stress and risk of stroke. *Arch Intern Med*. 2009;169(1):56-61. doi:10.1001/archinternmed.2008.503
10. Toivanen S, Hemström O. Is the impact of job control on stroke independent from socioeconomic status?: a large-scale study of the Swedish working population. *Stroke*. 2008;39(4):1321-1323. doi:10.1161/STROKEAHA.107.495523
11. Karlsson B. Is there an association between shift work and having a metabolic syndrome? Results from a population based study of 27,485 people. *Occup Environ Med*. 2001;58(11):747-752. doi:10.1136/oem.58.11.747
12. Wu WT, Tsai SS, Wang CC, et al. Professional driver's job stress and 8-year risk of cardiovascular disease: the Taiwan bus driver cohort study. *Epidemiology*. 2019;30(Suppl 1):S39-S47. doi:10.1097/EDE.0000000000001003
13. Jood K, Karlsson N, Medin J, et al. The psychosocial work environment is associated with risk of stroke at working age. *Scand J Work Environ Health, Environ Health*. 2017;43(4):367-374.
14. Theorell T, Hogstedt C, Sjogren B. Occupational chemical exposures and cardiovascular disease. *Swed Agency Health Technol Assess Assess Soc Serv*. 2017;261E:4.
15. Berg ZK, Rodriguez B, Davis J, Katz AR, Cooney RV, Masaki K. Association between occupational exposure to pesticides and cardiovascular disease incidence: the Kuakini Honolulu heart program. *J Am Heart Assoc*. 2019;8(19):e012569. doi:10.1161/JAHA.119.012569
16. Fujino Y, Iso H, Tamakoshi A, JACC study Group. A prospective cohort study of perceived noise exposure at work and cerebrovascular diseases among male workers in Japan. *J Occup Health*. 2007;49(5):382-388. doi:10.1539/joh.49.382
17. Howard VJ, Cushman M, Pulley L, et al. The reasons for geographic and racial differences in stroke study: objectives and design. *Neuroepidemiology*. 2005;25(3):135-143. doi:10.1159/000086678
18. Howard G, Howard VJ. Twenty years of progress toward understanding the stroke belt. *Stroke*. 2020;51(3):742-750. doi:10.1161/STROKEAHA.119.024155
19. MacDonald LA, Pulley L, Hein MJ, Howard VJ. Methods and feasibility of collecting occupational data for a large population-based cohort study in the United States: the reasons for geographic and racial differences in stroke study. *BMC Public Health*. 2014;14:142. doi:10.1186/1471-2458-14-142
20. Howard VJ, Kleindorfer DO, Judd SE, et al. Disparities in stroke incidence contributing to disparities in stroke mortality. *Ann Neurol*. 2011;69(4):619-627. doi:10.1002/ana.22385
21. World Health Organization (WHO) Stroke—1989: recommendations on stroke prevention, diagnosis, and therapy. report of the WHO task force on stroke and other cerebrovascular disorders. *Stroke*. 1989;20(10):1407-1431. doi:10.1161/01.str.20.10.1407
22. Biswas A, Harbin S, Irvin E, et al. Sex and gender differences in occupational hazard exposures: a scoping review of the recent literature. *Curr Environ Health Rep*. 2021;8(4):267-280. doi:10.1007/s40572-021-00330-8
23. International Labor Organization (ILO). Gender and occupational safety and health (occupational safety and health). Accessed February 14, 2022. https://www.ilo.org/safework/areasofwork/gender-and-occupational-safety-and-health/lang–en/index.htm
24. D'Agostino RB, Wolf PA, Belanger AJ, Kannel WB. Stroke risk profile: adjustment for antihypertensive medication. the framingham study. *Stroke*. 1994;25(1):40-43. doi:10.1161/01.STR.25.1.40
25. McClure LA, Kleindorfer DO, Kissela BM, Cushman M, Soliman EZ, Howard G. Assessing the performance of the Framingham Stroke Risk Score in the reasons for geographic and racial differences in stroke cohort. *Stroke*. 2014;45(6):1716-1720. doi:10.1161/STROKEAHA.114.004915
26. Yelland LN, Salter AB, Ryan P. Performance of the modified Poisson regression approach for estimating relative risks from clustered prospective data. *Am J Epidemiol*. 2011;174(8):984-992. doi:10.1093/aje/kwr183
27. Zou G. A modified poisson regression approach to prospective studies with binary data. *Am J Epidemiol*. 2004;159(7):702-706. doi:10.1093/aje/kwh090
28. Kromhout H, Vermeulen R. Long-term trends in occupational exposure: are they real? What causes them? What shall we do with them? *Ann Occup Hyg*. 2000;44(5):325-327. doi:10.1093/annhyg/44.5.325
29. R: The R Project for Statistical Computing. Accessed November 2, 2021. https://www.r-project.org/
30. R Core Team. 2018. R: a language and environment forstatistical computing. RFoundation for Statistical Computing. https://www.R-project.org/
31. Soteriades ES, Smith DL, Tsismenakis AJ, Baur DM, Kales SN. Cardiovascular disease in US firefighters: a systematic review. *Cardiol Rev*. 2011;19(4):202-215. doi:10.1097/CRD.0b013e318215c105
32. Noh J, Lee CJ, Hyun DS, et al. Blood pressure and the risk of major adverse cardiovascular events among firefighters. *J Hypertens*. 2020;38(5):850-857. doi:10.1097/HJH.0000000000002336
33. Zwirn SA. *Examining the 72 consecutive hour work limit*. Thesis. National Fire Academy; 2007.
34. Kim BJ, Lee SH, Ryu WS, et al. Excessive work and risk of haemorrhagic stroke: a nationwide case-control study. *Int J Stroke*. 2013;8(SA100):56-61. doi:10.1111/j.1747-4949.2012.00949.x
35. Alexeeff SE, Liao NS, Liu X, Van Den Eeden SK, Sidney S. Long-term PM2.5 exposure and risks of ischemic heart disease and stroke events: review and meta-analysis. *J Am Heart Assoc*. 2021;10(1):e016890. doi:10.1161/JAHA.120.016890
36. Choi B, Dobson M, Schnall P, Garcia-Rivas J. 24-hour work shifts, sedentary work, and obesity in male firefighters. *Am J Ind Med*. 2016;59(6):486-500. doi:10.1002/ajim.22572
37. Sieber WK, Robinson CF, Birdsey J, et al. Obesity and other risk factors: the national survey of U.S. long-haul truck driver health and injury. *Am J Ind Med*. 2014;57(6):615–626. doi:10.1002/ajim.22293

38. Shah RS, Cole JW. Smoking and stroke: the more you smoke the more you stroke. *Expert Rev Cardiovasc Ther*. 2010;8(7):917-932. doi:10.1586/erc.10.56
39. Luckhaupt SE, Calvert GM, Centers for Disease Control and P. Prevalence of coronary heart disease or stroke among workers aged <55 years—United States, 2008–2012. *MMWR Morb Mortal Wkly Rep*. 2014;63(30):645-649.
40. Alterman T, Luckhaupt SE, Dahlhamer JM, Ward BW, Calvert GM. Prevalence rates of work organization characteristics among workers in the U.S.: data from the 2010 National Health Interview Survey. *Am J Ind Med*. 2013;56(6):647-659. doi:10.1002/ajim.22108
41. Wu MT, Lin PC, Pan CH, Peng CY. Risk assessment of personal exposure to polycyclic aromatic hydrocarbons and aldehydes in three commercial cooking workplaces. *Sci Rep*. 2019;9(1):1661. doi:10.1038/s41598-018-38082-5
42. Lewné M, Johannesson S, Strandberg B, Bigert C. OUP accepted manuscript. *Ann Work Expo Health*. 2016;61(2):152-163. doi:10.1093/annweh/wxw027
43. Burstyn I, Kromhout H, Partanen T, et al. Polycyclic aromatic hydrocarbons and fatal ischemic heart disease. *Epidemiology*. 2005;16(6):744-750. doi:10.1097/01.ede.0000181310.65043.2f
44. Stallings-Smith S, Peterson B, Gellers JC. Association between exposure to polycyclic aromatic hydrocarbons and stroke among adults in the United States. *ISEE Conf Abstr*. Published online October 26, 2020. doi:10.1289/isee.2020.virtual.P-0157
45. MacDonald LA, Bertke S, Hein MJ, et al. Prevalence of cardiovascular health by occupation: a cross-sectional analysis among U.S. workers aged ≥45 years. *Am J Prev Med*. 2017;53(2):152-161. doi:10.1016/j.amepre.2017.02.022
46. Lloyd-Jones DM, Hong Y, Labarthe D, et al. Defining and setting national goals for cardiovascular health promotion and disease reduction. *Circulation*. 2010;121(4):586-613. doi:10.1161/CIRCULATIONAHA.109.192703
47. CDC. *Workplace Health Promotion*. CDC; 2021. Accessed February 14, 2022. https://www.cdc.gov/workplacehealthpromotion/index.html
48. Schill AL, Chosewood LC. The NIOSH Total Worker Health™ Program: an overview. *J Occup Environ Med*. 2013;55:S8-S11. Accessed January 26, 2022. doi:10.1097/JOM.0000000000000037
49. Trudel X, Gilbert-Ouimet M, Vézina M, et al. Effectiveness of a workplace intervention reducing psychosocial stressors at work on blood pressure and hypertension. *Occup Environ Med*. 2021;78(10):738-744. doi:10.1136/oemed-2020-107293
50. Bourbonnais R, Brisson C, Vezina M. Long-term effects of an intervention on psychosocial work factors among healthcare professionals in a hospital setting. *Occup Environ Med*. 2011;68(7):479-486. doi:10.1136/oem.2010.055202
51. Lamontagne AD, Keegel T, Louie AM, Ostry A, Landsbergis PA. A systematic review of the job-stress intervention evaluation literature, 1990–2005. *Int J Occup Environ Health*. 2013;13:268-280. doi:10.1179/oeh.2007.13.3.268
52. Fox K, Johnson S, Berkman L, et al. Organisational- and group-level workplace interventions and their effect on multiple domains of worker well-being: a systematic review. *Work Stress*. 2022;36:30-59.
53. Macdonald LA, Fujishiro K, Howard VJ, Landsbergis P, Hein MJ. Participation in a US community-based cardiovascular health study: investigating non-random selection effects related to employment, perceived stress, work-related stress, and family caregiving. *Ann Epidemiol*. 2017;27:545-552. doi:10.1016/j.annepidem.2017.08.008

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Huynh TB, McClure LA, Howard VJ, Stafford MM, Judd SE, Burstyn I. Duration of employment within occupations and incident stroke in a US general population cohort 45 years of age or older (REGARDS study). *Am J Ind Med*. 2023;66:142-154. doi:10.1002/ajim.23446