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Parental divorce's long shadow: Elevated stroke risk among older Americans

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Abstract

Although studies have investigated the association between adverse childhood experiences and chronic health outcomes including stroke, few studies have investigated the association between parental divorce and stroke among adults with no history of childhood abuse. The objectives of this study were to investigate the association between parental divorce in childhood and stroke in older adulthood among those who did not experience child abuse and to examine whether this association differs between men and women. This study utilized population-based data from the 2022 Behavioral Risk Factor Surveillance System. An analytic sample of 13,205 adults aged 65 and above (56.6% female) who have never experienced childhood physical nor sexual abuse were analyzed using binary logistic regression. The outcome variable investigated was self-report of a physician-diagnosis of stroke, and the main exposure of interest was parental divorce. In this sample of older adults, 7.3% reported having stroke, while 13.9% reported that their parents had divorced before the respondent was 18 years old. Controlling for the effects of other factors, respondents who experienced parental divorce had 1.61 times higher odds of having a stroke when compared to their counterparts who did not experience parental divorce (AOR = 1.61, 95% CI = 1.15–2.24). The association between parental divorce and stroke was not dependent on sex; however, compared to females, males had 1.47 times higher odds of having a stroke (AOR = 1.47, 95% CI = 1.11–1.93). The findings of this study suggest that individuals in this cohort whose parents divorced as children were at greater risk for stroke later in life. Potentially moderating variables were hypothesized, including childhood poverty, sleep hygiene, and hypertension.

Introduction

Each year approximately 795,000 individuals in the United States (U.S.) have a stroke [1, 2]. For one in five of these individuals, the stroke is fatal, making strokes the fifth leading cause of

death in the U.S. [3]. An estimated two-thirds of stroke survivors experience impaired mobility [4], over half of survivors experience cognitive impairment [1], and many can no longer live independently in the community [5]. In addition to the substantial direct economic impact of medical care costs, there are many indirect consequences of a stroke, including lost productivity and increased care needs [6]. The combined direct and indirect annual cost of stroke to the U.S. economy is estimated to be about $56.5 billion [7].

There are many known risk factors for stroke. Sociodemographic risk factors for stroke include older age [7], female sex [7], being Black [8], being widowed or divorced [9], lower socioeconomic status (SES) [10], and living in rural areas [11]. Health behaviors that increase the risk of stroke include smoking, heavy drinking, inadequate physical activity, and higher body mass index (BMI) [12, 13]. Given the high prevalence of stroke and the significant economic burden associated with the disease, it is important to gain more knowledge about potentially modifiable risk factors.

Recent research suggests that adverse childhood experiences (ACEs) increase the risk of stroke in adulthood [14, 15]. ACEs are a broad term that encompasses distressing and potentially harmful events of sexual, physical or emotional abuse, neglect, or family dysfunction such as parental incarceration, parental mental illness, parental substance abuse, or parental divorce [16–18]. Estimates shows that more than three in five American adults experienced at least one ACE in their childhood, with one in six experiencing four or more ACEs [16, 18]. The number of ACEs experienced increases the risk for negative health outcomes, including having a stroke [14, 15, 19]. Research indicates that women who experienced sexual or physical abuse as a child are at greater risk for stroke [20] and both men and women with a history of childhood maltreatment are at higher risk for cardiovascular disease [21, 22]. Exposure to physical neglect as a child also increases stroke risk [23].

Although studies have investigated the association between ACEs and chronic health outcomes including stroke, few studies have investigated the association between parental divorce and stroke among adults with no history of childhood abuse. Parental divorce or separation has been found to be associated with a range of adverse health outcomes in adulthood including poorer mental health [24–26], suicidal ideation [27], lower self-rated health [28], and higher lifetime morbidity [29]. Parental divorce has also been linked with unhealthy behaviors and conditions such as cigarette smoking [30, 31], substance use disorders [32], and obesity [33]. In turn, these health risk behaviors increase the risk of stroke [12, 34–39]. Other known risk factors for stroke such as depression [40] and diabetes [41], are also elevated among adults who experienced parental separation or divorce during childhood [26, 29].

Our previous research examined the association between parental divorce and stroke using the population-based 2010 Behavioral Risk Factor Surveillance System [42]. Because our interest was in parental divorce in the absence of other childhood adversities, our analysis excluded those who had, during their childhood, experienced parental substance abuse, parental domestic violence, or any form of childhood abuse (physical, sexual, or emotional). Even after accounting for sociodemographic factors, our study found that parental divorce significantly elevated the odds of stroke among men aged 18 and older [42]. Although the odds of stroke were elevated among women who had experienced parental divorce, this association did not reach statistical significance. However, the number of women with a stroke in our previous study was relatively small (n = 129) and the age range was 18 and older [42], despite the majority of strokes occurring in later life [7]. To our knowledge, this study has not yet been replicated with more recent population-based data or with a focus solely on stroke as opposed to a combination of stroke and heart disease (e.g. [43]).

Thus, using a large representative sample of community-dwelling Americans aged 65 and older, the objectives of this study were: (1) To investigate the cross-sectional association

between parental divorce in childhood and stroke in older adulthood among those who did not experience child abuse; and (2) To examine whether this association differs between men and women. We hypothesized that, controlling for sociodemographic characteristics, other ACEs, social support, health behaviors, chronic health conditions, and the presence of an adult who made the respondent feel safe and protected during childhood, respondents who experienced parental divorce during childhood would have higher odds of having a stroke. We further hypothesized that the association between parental divorce and stroke vary by sex.

Materials and methods

Data source and sample

Our study was based upon secondary analysis of the public use dataset of the Behavioral Risk Factor Surveillance System (BRFSS) [44] funded by the Centers for Disease Control and Prevention (CDC). Because the public-use data have no individually identifiable information, ethics approval was not required to conduct the current study. The data was accessed for research purposes on July 16, 2024. The BRFSS is a cross-sectional survey conducted annually by the CDC to gather data on health-related risk behaviors, chronic health conditions, and use of preventive services from non-institutionalized U.S. adult population aged 18 and above [45]. Detailed information on the design of the 2022 BRFSS, including the objectives, methodology, and sampling procedure, are available from the U.S. Department of Health and Human Services and the CDC [46]. The authors have also provided a detailed description of the methods and variables in other publications [31, 42]. The 2022 BRFSS was approved by the CDC's Institutional Review Board, and the de-identified data are publicly available. The BRFSS questionnaire consists of core components, optional modules, and state-added questions. The 2022 optional survey module on ACEs was answered by all respondents aged 18 and older in eight states (Arkansas, Florida, Iowa, Nevada, North Dakota, Oregon, South Dakota, and Virginia). The initial sample size for the 2022 BRFSS was 445,132 respondents across all 50 states. When the sample was restricted to individuals aged 65 and older who lived in the eight states that administered the ACEs module and who had not been sexually or physically abuse, the sample size decreased to 14,454. Of these 14,454 respondents, a total of 1,249 individuals (8.6%) had missing data on one or more of the variables included in the analysis, and these respondents were excluded using listwise deletion, resulting in a final sample size was 13,205. The prevalence of missing data was only 0.3% for the outcome of interest (stroke), and 1.0% for the key exposure of interest (parental divorce). The prevalence of missing data among the control variables ranged from a high of 1.5% (i.e., heavy alcohol use) to a low of 0.2% (i.e., level of education). Research suggests that using listwise deletion when less than 10% of the data are missing provides comparable estimates to other methods of dealing with missing data [47].

Outcome variable

The outcome variable examined in this study was self-reported physician diagnosis of stroke, and it was measured as a binary variable based on response to the question, "Has a doctor, nurse, or other health professional EVER told you that you had a stroke?" Respondents who answered "Yes" were coded as 1, whereas respondents who answered "No" were coded as 0. This item has been used in other population-based studies and provides reliable overall measure of stroke [42, 48, 49].

Main exposure of interest

The main exposure of interest examined in this this study was parental divorce and was measured as a binary variable based on response to the question, "Before you were 18 years of age, were your parents separated or divorced?" with the following response options, "Yes," "No," and "Parents not married." Respondents who answered "Yes" were coded as 1, whereas respondents who answered "No" were coded as 0. Respondents whose parents were not married were excluded from the analysis.

Covariates

Covariates examined in this study were grouped under SES (education and household income), ACEs (emotional abuse, household mental illness, household substance use, household incarceration, and witnessed domestic violence), feeling safe and protected by an adult in the household, social support (marital status and social and emotional support), health behaviors (heavy drinking, cigarette smoking, BMI, and physical activity), and health conditions (depression and diabetes). Detailed information about how each covariate was measured and the exact questionnaire wording is provided in S1 Table (See S1 Table).

Demographic characteristics

The following demographic characteristics were considered. Age was measured as an ordinal variable into the following categories "0 = 65–69 years," "1 = 70–74 years," "2 = 75–79 years," and "3 = 80 years and above." Sex of the respondent was coded as a binary variable with female as the reference category. Race/ethnicity was measured as a nominal variable into the following categories "Non-Hispanic White," "Non-Hispanic Black," and "Hispanic, Other race." Rural/urban status was coded as a binary variable with urban as the reference category.

Data analyses

The analytic procedure involved using descriptive, bivariate, and multivariable analytical techniques. First, the general distribution of all the variables was examined using frequencies and percentages. Second, Pearson chi-square test of association was conducted to examine the bivariate association between the study variables and stroke. Third, binary logistic regression was then employed to examine the cross-sectional association between parental divorce and stroke among respondents who have never experienced childhood physical or sexual abuse. Three logistic regression models were fitted. In Model 1, we regressed stroke on parental divorce and the demographic variables given their a priori importance. Model 2 consists of variables in Model 1 plus SES factors (education and household income). Model 3, which is the fully adjusted model, consists of variables in Model 2 plus all the other covariates. To investigate whether the effects of parental divorce on stroke is dependent on sex, we conducted a two-way interaction between parental divorce and sex on stroke while simultaneously controlling for the effects of demographic characteristics and other covariates. We found that the interaction was not significant, hence we reverted to examining the main effects. Adjusted odds ratio (AOR) and 95% Confidence Intervals (CI) are reported. All analyses were two-tailed, and variables were considered significant if the *p*-value was less than .05 or the 95% CI does not contain 1. To account for the weighting and complexity of the sampling design employed by the BRFSS, we used Stata's "svyset" command. Although missing data were handled using listwise deletion, sampling weights were still applied to the remaining data to ensure that the analysisrepresents the population proportions as intended in the original sampling design. This is especially important in complex survey data such as the BRFSS where the

sample is not representative of the population without weighting. All analyses were performed using Stata version MP 17.

Results

Sample characteristics

Table 1 shows the general distribution of the sample characteristics and the bivariate association between stroke and the sample characteristics. Of the 13,205 adults aged 65 and above who have never experienced childhood physical or sexual abuse, 7.3% had self-reported a physician diagnosis of stroke. About one in seven respondents (13.9%) experienced parental divorce. There were significant bivariate associations between a number of variables and stroke. For instance, 11.2% of respondents who experienced parental divorce, compared to 7.5% of respondents who did not experience parental divorce, had a stroke ($\chi^2(1) = 24.70$, $p < .001$). Respondents were more likely to have a stroke if they: were older, were male, lived in a rural county, had low income, experienced neglect, experienced household substance use, witnessed domestic violence, or did not feel safe and protected by an adult in the household all the time. About 10.7% of respondents who were separated/divorced compared to 8.8% of respondents who were widowed, 7.9% of respondents who were single/never married, and 6.7% of respondents who were married reported that they had been diagnosed with a stroke ($\chi^2(3) = 37.40$, $p < .001$). The prevalence of stroke was significantly higher amongrespondents who currently smoked (11.2%) compared to former smokers (8.5%) and those who had never smoked (7.1%) ($\chi^2(2) = 24.51$, $p < .001$). About 10.9% of respondents who were physically inactive compared to 6.7% of respondents who were physically active reported that they had been diagnosed with a stroke ($\chi^2(1) = 68.45$, $p < .001$). The prevalence of stroke was significantly higher among respondents diagnosed with depression (11.2%) compared to those without a diagnosis of depression (7.4%; $\chi^2(1) = 27.25$, $p < .001$). Similarly, the prevalence of stroke was significantly higher among respondents diagnosed with diabetes (11.9%) compared to those without a diagnosis of diabetes (6.8%; $\chi^2(1) = 78.53$, $p < .001$).

Multivariable logistic regression results

Table 2 shows the results of the multivariable logistic regression analysis of the association between parental divorce and stroke among respondents who have never experienced childhood physical or sexual abuse. Controlling for demographic factors in Model 1, we found that respondents who experienced parental divorce had 1.73 times higher odds of having a stroke when compared to their counterparts who did not experience parental divorce (AOR = 1.73, $p = .001$, 95% CI = 1.26–2.37). This significant association was partially attenuated with the addition of SES factors in Model 2, and other covariates in Model 3. In the fully adjusted model, respondents who experienced parental divorce had 1.61 times higher odds of having a stroke when compared to their counterparts who did not experience parental divorce (AOR = 1.61, $p = .005$, 95% CI = 1.15–2.24).

Compared to respondents aged 65–69, the odds of having a stroke were 1.74 times higher for respondents aged 75–79 (AOR = 1.74, $p = .006$, 95% CI = 1.17–2.57) and 2.11 times higher for respondents aged 80 and above (AOR = 2.11, $p < .001$, 95% CI = 1.38–3.21). Compared to females, males had 1.47 times higher odds of having a stroke (AOR = 1.47, $p = .006$, 95% CI = 1.11–1.93). Respondents were more likely to have a stroke if they make less than $35,000 in household income. Depression and diabetes were both significantly positively associated with stroke. Respondents diagnosed with depression had 1.76 times higher odds of having a stroke (AOR = 1.76, $p = .002$, 95% CI = 1.22–2.54) and respondents diagnosed with diabetes

Table 1. Sample characteristics and percent with diagnosis of stroke (N = 13,205).

Variable			Unweighted Frequency	Weighted %	% with Stroke	Chi-square (p-value)
Outcome variable						
	Stroke					
		No	12,164	92.7		
		Yes	1,041	7.3		
Exposure variable of interest						
	Parental divorce					
		No	11,781	86.1	7.5	24.70 ($p < .001$)
		Yes	1,424	13.9	11.2	
Demographic variables						
	Age					69.58 ($p < .001$)
		65–69 years	3,572	27.5	5.9	
		70–74 years	3,516	30.2	6.7	
		75–79 years	2,773	19.1	8.4	
		80 years and above	3,344	23.2	10.9	
	Sex					17.65 ($p < .001$)
		Female	7,627	56.6	7.0	
		Male	5,578	43.4	9.0	
	Race					5.30 ($p = .070$)
		Non-Hispanic White	12,015	79.1	7.8	
		Non-Hispanic Black	588	8.5	10.4	
		Hispanic/Other race	602	12.4	7.5	
	Rural urban county					5.90 ($p = .015$)
		Urban county	10,278	90.3	7.6	
		Rural county	2,927	9.7	9.0	
Socioeconomic status						
	Education					63.55 ($p < .001$)
		Graduated from college/technical school	5,318	30.8	6.0	
		Attended college/technical school	3,820	31.8	7.7	
		High school or less	4,067	37.4	10.5	
	Household income					123.56 ($p < .001$)
		$75,000 and above	3,192	24.2	5.3	
		$50,000-$74,999	2,097	13.7	7.2	
		$35,000-$49,999	1,932	12.0	7.3	
		$20,000-$34,999	2,318	17.6	10.3	
		Less than $20,000	864	8.0	15.6	
		Missing data	2,802	24.5	7.4	
Adverse childhood experiences						
	Emotional abuse					0.50 ($p = .477$)
		No	11,100	85.0	7.8	
		Yes	2,105	15.0	8.3	
	Neglect					17.68 ($p < .001$)
		No	12,959	96.1	7.8	
		Yes	246	3.9	15.0	
	Household mental illness					0.63 ($p = .426$)
		No	12,307	94.2	7.8	
		Yes	898	5.8	8.6	
	Household substance use					9.76 ($p = .002$)

(*Continued*)

Table 1. (Continued)

Variable			Unweighted Frequency	Weighted %	% with Stroke	Chi-square (p-value)
		No	11,034	85.2	7.6	
		Yes	2,171	14.8	9.5	
	Household incarceration					3.50 (p = .061)
		No	12,972	97.8	7.8	
		Yes	233	2.2	11.2	
	Witnessed domestic violence					4.32 (p = .038)
		No	12,444	94.1	7.8	
		Yes	761	5.9	9.9	
	Felt safe and protected by an adult in the household all the time					4.96 (p = .026)
		Yes	11,293	84.4	7.7	
		No	1,912	15.6	9.2	
Social support						
	Marital status					37.40 (p < .001)
		Married	6,996	59.1	6.7	
		Separated/Divorced	1,714	12.0	10.7	
		Widowed	3,636	23.4	8.8	
		Single/Never married	859	5.5	7.9	
	Social and emotional support					7.12 (p = .130)
		Always	3,222	35.9	7.9	
		Usually	1,629	15.9	6.9	
		Sometimes	475	5.3	7.8	
		Rarely/never	237	3.2	11.8	
		Missing data	7,642	39.7	8.0	
Health risk behaviors						
	Heavy alcohol use					0.71 (p = .401)
		No	12,590	95.2	7.9	
		Yes	615	4.8	7.0	
	Cigarette smoking					24.51 (p < .001)
		Never	7,451	56.4	7.1	
		Formerly smoked	4,745	36.4	8.5	
		Currently smoke	1,009	7.2	11.2	
	BMI					19.04 (p < .001)
		Normal	4,005	30.8	7.5	
		Overweight	4,740	34.9	8.0	
		Obese	3,811	29.0	8.8	
		Missing	649	5.3	4.0	
	Physical activity					68.45 (p < .001)
		Inactive	3,805	29.5	10.9	
		Active	9,400	70.5	6.7	
Chronic health conditions						
	Depression					27.25 (p < .001)
		No	11,593	87.6	7.4	
		Yes	1,612	12.4	11.2	
	Diabetes					78.53 (p < .001)
		No	10,436	76.7	6.8	
		Yes	2,769	23.3	11.9	

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Table 2. Multivariable logistic regression analysis of the association between parental divorce and stroke[a] (N = 13,205).

Variables			Model 1		Model 2		Model 3	
			AOR (95% C.I)	*p*-value	AOR (95% C.I)	*p*-value	AOR (95% C.I)	*p*-value
Key variable of interest								
	Parental divorce (No)							
		Yes	1.73 (1.26–2.37)	.001	1.65 (1.20–2.28)	.002	1.61 (1.15–2.24)	.005
Demographic variables								
	Age (65–69 years)							
		70–74 years	0.92 (0.63–1.33)	.654	0.91 (0.63–1.31)	.611	0.93 (0.65–1.33)	.699
		75–79 years	1.72 (1.16–2.54)	.007	1.68 (1.14–2.49)	.009	1.74 (1.17–2.57)	.006
		80 years and above	2.09 (1.43–3.03)	< .001	1.89 (1.29–2.79)	.001	2.11 (1.38–3.21)	.001
	Sex (Female)							
		Male	1.36 (1.05–1.76)	.019	1.41 (1.08–1.83)	.010	1.47 (1.11–1.93)	.006
	Race (Non-Hispanic White)							
		Non-Hispanic Black	1.16 (0.75–1.79)	.515	1.02 (0.64–1.62)	.933	0.98 (0.62–1.53)	.921
		Hispanic/Other race	0.28 (0.14–0.57)	< .001	0.22 (0.11–0.46)	< .001	0.22 (0.11–0.47)	< .001
	Rural urban county (Urban county)							
		Rural county	1.29 (1.00–1.68)	.050	1.10 (0.84–1.45)	.498	1.06 (0.82–1.38)	.639
Socioeconomic status								
	Education (Graduated from college/technical school)				1.12 (0.83–1.49)	.458	1.09 (0.81–1.47)	.569
		Attended college/technical school			1.39 (1.05–1.85)	.020	1.35 (1.02–1.78)	.037
		High school or less						
	Household income ($75,000 and above)							
		$50,000-$74,999			1.55 (1.07–2.26)	.021	1.42 (0.98–2.07)	.067
		$35,000-$49,999			1.50 (1.00–2.26)	.053	1.35 (0.88–2.06)	.169
		$20,000-$34,999			2.50 (1.70–3.66)	< .001	2.13 (1.45–3.11)	< .001
		Less than $20,000			2.60 (1.60–4.21)	< .001	2.01 (1.23–3.29)	.006
		Missing data			1.29 (0.89–1.89)	.182	1.18 (0.77–1.80)	.441
Adverse childhood experiences								
	Emotional abuse (No)							
		Yes					1.10 (0.79–1.53)	.585
	Neglect (No)							
		Yes					0.93 (0.42–2.07)	.858
	Household mental illness (No)							
		Yes					1.03 (0.69–1.54)	.886
	Household substance use (No)							
		Yes					1.11 (0.82–1.50)	.514
	Household incarceration (No)							
		Yes					0.89 (0.44–1.81)	.755
	Exposure to domestic violence (No)							
		Yes					1.09 (0.63–1.87)	.756
	Felt safe and protected all the time (Yes)							
		No					0.87 (0.62–1.23)	.447
Social support								
	Marital status (Married)							
		Divorced/separated					1.38 (0.99–1.92)	.056
		Widowed					0.96 (0.67–1.37)	.802
		Single/Never married					0.99 (0.63–1.54)	.948

(*Continued*)

Table 2. (Continued)

Variables			Model 1		Model 2		Model 3	
			AOR (95% C.I)	*p*-value	AOR (95% C.I)	*p*-value	AOR (95% C.I)	*p*-value
	Emotional support (Always)							
		Usually					0.81 (0.51–1.27)	.352
		Sometimes					0.71 (0.38–1.35)	.302
		Rarely/never					1.23 (0.62–2.43)	.550
		Missing data					1.09 (0.80–1.50)	.574
Health risk behaviors								
	Heavy alcohol use							
		Yes					0.82 (0.48–1.39)	.459
	Cigarette smoking (Never)							
		Formerly smoked					1.03 (0.79–1.35)	.814
		Currently smoke					1.17 (0.78–1.74)	.442
	BMI (Normal)							
		Overweight					0.93 (0.69–1.27)	.659
		Obese					0.95 (0.70–1.28)	.725
		Missing					1.10(0.43–0.83)	.843
	Physical activity (Inactive)							
		Active					0.75 (0.58–0.98)	.035
Chronic health conditions								
	Depression							
		Yes					1.76 (1.22–2.54)	.002
	Diabetes (No)							
		Yes					1.37 (1.03–1.81)	.031

Reference category is indicated in parenthesis

[a]Among respondents who had never experienced childhood physical or sexual abuse

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had 1.37 times higher odds of having a stroke (AOR = 1.37, p = .031, 95% CI = 1.03–1.81) both when compared to their counterparts without such diagnoses.

Discussion

The objectives of this study were to examine the association between parental divorce and stroke, and whether this association differs between men and women using a large, representative, cross-sectional sample of community-dwelling older Americans with no history of childhood physical and/or sexual abuse. When compared with those who did not experience parental divorce, children of divorced parents had 1.61 times higher odds of having a stroke. Our current study found that the interaction between divorce and sex on stroke was statistically not significant. That is to say, the association between parental divorce and stoke did not vary by sex. However, there was a significant main effect of sex on stroke with males having 1.47 times higher odds of having a stroke when compared to females.

The non-significant interaction between divorce and sex on stroke in our current study is in contrast to our previous study in which the parental divorce -stroke association was only significant for men (AOR = 3.01; 95% CI = 1.68, 5.39), albeit with very wide confidence intervals. Although the association between parental divorce and stroke for women in our earlier study generated odds very similar (AOR = 1.64; 95% CI = 0.89, 3.02) to the ones for the combined sexes in our current study (AOR = 1.61, 95% CI = 1.15–2.24), the association in our

earlier study did not reach statistical significance for women [42]. The current study is focused on a higher risk subgroup (those aged 65 and older vs. those aged 18 and older). We therefore found a higher percentage of women who reported a stroke in our current study (7.3%) versus 2.13% in our previous study [42], which leads to greater statistical power. We anticipate that the presence of a statistically significant association between parental divorce and stroke for women in the current study but not in our earlier study could be due to the greater statistical power in the current study.

The association between parental divorce and stroke in the current study remained even after controlling for known risk factors of stroke, such as diabetes [41], depression [40], and a small social support network [50]. It is interesting to note that the association between parental divorce and stroke is comparable in magnitude to the association between two well established risk factors for stroke: diabetes and depression. Respondents with diabetes had 1.37 times higher odds of having a stroke when compared to those without diabetes, respondents with depression had 1.76 times higher odds when compared to those without depression, and respondents with a history of parental divorce had 1.61 times higher odds when compared to those without a history of parental divorce. The connections between depression and stroke [40, 51, 52] and diabetes and stroke [53–55] have been significant areas of focus in the research literature. In contrast, the connection between parental divorce and stroke risk remains understudied; to our knowledge, no research study with a sole focus on parental divorce and stroke as opposed to a combination of stroke and heart disease (e.g., [43]) has been conducted since the publication of our previous study [42]. By specifically focusing on stroke in our research, we were able to isolate and measure a distinct acute cardiovascular event and examine the factors associated with it.

Childhood physical and sexual abuse have been found to be significantly associated with adult stroke risk [20]. Finding an association between parental divorce and stroke risk in the absence of childhood sexual and physical abuse is an important addition to the extant literature suggesting that even when a child did not experience physical or sexual abuse, their parents' marriage dissolution may be associated with adverse long-term health outcomes including stroke.

Although we cannot determine the mechanism linking parental divorce and stroke with our current data, we have several hypotheses which warrant future research. Parental divorce is a source of substantial stress for many children, as displayed through higher rates of emotional and behavioral disruption [56] and poorer mental health [57] following parental divorce. The Biological Embedding theory presents an explanation as to how exposure to prolonged stress could lead to long-term negative health outcomes [58]. This theory purports that exposure to high levels of stress during childhood may disrupt the hypothalamic-pituitary-adrenal (HPA) axis, the brain's stress response pathway [58]. In response to stress, the HPA axis stimulates the release of hormones which lead to the adrenal glands releasing glucocorticoids, primarily cortisol [59]. Working in tandem with the autonomic nervous system and immune systems, the HPA axis prepares the body to respond to stressful situations [60]. When a child is exposed to prolonged stress, such as the stress associated with parental divorce (parental fighting, household tension, moving to a new home or school, etc.), their HPA axis may become dysregulated [61]. Previous research has demonstrated that disruption to the HPA axis is associated with cardiovascular disease [62] and major depressive disorder [63]. Thus, it is possible that parental divorce may act as a catalyst for chronic stress which has the potential to disrupt the HPA axis, which in turn could heighten stroke risk in adulthood. Because of the use of a cross-sectional dataset and the fact that the BRFSS did not include information on HPA axis, our current study cannot confirm that HPA axis dysregulation is the mechanism connecting parental divorce and stroke risk. Future researchers should

consider using longitudinal designs in order to better study this connection. However, the existing research literature does suggest that stress increases the risk of stroke [64] and dysregulation to the HPA axis is associated with worse stroke outcomes [65, 66].

Previous research has also indicated a link between hypertension (high blood pressure) and both parental divorce [67] and stroke risk [13]. Children of divorced parents are at risk for developing hypertension [67], and individuals with hypertension are at elevated risk for stroke [13]. The dataset used for our current study did not include information on hypertension; thus, we were unable to examine whether hypertension mediated the association between parental divorce and stroke risk in our study. Future research should examine whether lifetime hypertension mediates the association between parental divorce and stroke risk.

Furthermore, previous research has established that individuals who experience sleep disorders are at greater risk for stroke [68]. Parental divorce has also been found to be associated with sleep disruption among children [69] with the negative effects of parental divorce on insomnia symptoms persisting into adulthood [70]. The BRFSS dataset did not include information on sleep, and as a result, we were unable to control for sleep disorders. Future research should examine whether sleep disorders or sleep disruption play a role in mediating the association between parental divorce and stroke.

Another factor that may help explain the association between parental divorce and stroke risk is childhood poverty. In the current study, we controlled for respondents' current income, but did not have information on respondents' income during childhood. There is a higher prevalence of parental divorce among low-income families [71, 72] and an increased risk of poverty particularly for women and children following a divorce [73–76]. The extant literature has found that children living in poverty are at greater risk for negative health outcomes including obesity [77] and chronic stress [78]. In addition, childhood poverty has been found to be a significant social determinant of health [79], and an important risk factor for stroke in adulthood [80–83]. Given the link between childhood poverty and stress [78], and between stress and stroke [64],future studies should take into account measures of childhood poverty to uncover the role it my play in the association between parental divorce and stroke.

In keeping with existing research literature, this study also found the following factors were associated with increased odds of stroke: having diabetes [41], having major depressive disorder [40], being divorced or widowed [9], older age [7], being Black [8], having low socioeconomic status [10], having low physical activity [13], and smoking [36]. The association found between sex and stroke risk is worth noting. Our findings showed that compared to females, males had 1.47 times higher odds of having a stroke. This finding contradicts past research that has found that compared to men, women have a higher life-time incidence of stroke [7]. Our cohort was 65+ and previous research has found that during this period of late adulthood, women have a one in five risk of stroke while men have approximately one in six risk of stroke [7].

Another finding worth noting is that a number of ACEs (i.e. neglect, witnessing domestic violence, not feeling safe and protected by an adult at home, and parental substance use) were significantly associated with stroke at the bivariate level, but once we controlled for other factors, these associations became non-significant in the multivariable logistic regression models. Previous research has established that those who experienced a greater number of ACEs ihave a higher stroke risk; however, those studies included individuals who had been physically and/or sexually maltreated in childhood [15], and our study did not.

Limitations

Our study has a number of limitations that should be discussed. The first limitation is related to the survivor selection effect. The respondents in this study, by nature of having survived

past 65, may not be representative of individuals who had strokes earlier in life which resulted in premature mortality or left them too incapacitated to complete a survey such as the BRFSS. Longevity and health are influenced by a number of biological and environmental factors [84] including greater social support [85], increased religious practice [86], and fewer unhealthy behaviors (e.g., smoking and excessive alcohol consumption) [84]. Thus, we anticipate that our sample of older Americans would have higher general well-being and have had fewer childhood adversities than those in their birth cohort who died prematurely. However, such a selection effect would have biased the results of the study towards the null, making it more difficult to establish a significant association between parental divorce and stroke.

Another factor worth noting and a potential limitation to the generalizability of these findings to future cohorts of older adults is that rates of parental divorce were quite rare in this cohort; just over 10% experienced parental divorce. The youngest of this cohort were born in 1957, over a decade before the U.S.'s first no-fault divorce bill was signed in 1969 [87]. Rates of divorce changed significantly over the second half of the 21st century: 2.2 per 1,000 population in 1959, 3.2 in 1969, 5.3 in 1979, 4.7 in 1989, and 4.2 in 1999 [88, 89]. The cohort examined in this study experienced parental divorce just before a national increase in divorce. We anticipate that our cohort experienced higher levels of divorce-related stigma from their community and peers during their childhood than did those in later birth cohorts, who grew up when parental divorce would have been more normative. Furthermore, among those in the cohort whose parents divorced, it may be that the level of parental conflict was particularly high in order that the parents would instigate a divorce in a time when divorce was more stigmatized and more challenging to obtain than it was in later years.

Another limitation is that we do not know at what point during their childhood the participants experienced parental divorce, nor the level of contact they had with the non-custodial parent. Previous research indicates that the impact of divorce varies by the child's age [90] and by the level of involvement of the non-custodial parent post-divorce [91]. Future research should focus on whether the age a child experiences parental divorce and the level of involvement with the non-custodial parent moderates future stroke risk. A limitation to the validity of this study was the reliance on self-report of a medical diagnosis of stroke which could allow for participant recall or reporting biases. It would have been preferable to have a chart-review. However, the sensitivity and specificity of self-report of a medical diagnosis of stroke has been found to be very high (95%) [92] and the item used in measuring stroke in this study has been used in other population-based studies and has been found to provide a reliable overall measure of stroke [48, 49]. Another limitation was the lack of information in the dataset on stroke characteristics, such as type of stroke (ischemic, hemorrhagic, etc.), severity of stroke, and age at which it occurred. Research supports that some factors elevate the risk of a particular type of stroke over others; for example, hypertension is more strongly associated with risk of intracerebral hemorrhage than ischemic stroke [13]. Thus, future research should examine whether parental divorce is associated with greater risk for a particular type of stroke. If this is the case, then this may help illuminate the mechanism by which parental divorce and stroke risk are connected.

Moreover, we were not able to control for several known risk factors for stroke including genetic predisposition [93], lifetime use of oral contraceptives [94], history of transient ischemic attacks [95], magnitude and duration of high blood pressure [13], high blood cholesterol [96], or high red blood cell counts [97], as these measures were not available in the BRFSS. Future research should examine the potential that these factors have to mediate the relationship between parental divorce and stroke risk.

Lastly, our use of a cross-sectional design limits interpretation of the study's findings. Although we found evidence that experiencing parental divorce is associated with higher

stroke risk in adulthood, we cannot interpret this association to be causal. Future research should employ longitudinal designs, rather than rely on retrospective recall of early childhood experiences such as parental divorce, in order to better examine the potential for a causal relationship between parental divorce and stroke incidence.

Conclusion

In conclusion, we found that experiencing parental divorce in childhood was associated with increased odds of stroke in a population-based cohort of Americans aged 65 and older who had never experienced childhood physical or sexual abuse. The findings built on our earlier study on the topic [42] in a few key ways. Our previous study used data from the 2010 BRFSS while our current study uses data from the 2022 BRFSS survey. This means that our current study is examining the next generation of older Americans. Before analyzing this newer data set, it was unclear if, because of societal and cultural changes between and during the World Wars, the connection found between parental divorce and stroke risk in the older cohort would be found again in a more recent cohort of older Americans. Thus, replicating these earlier findings with a newer cohort contributed to our knowledge of the association. Our previous study found support for a significant association between parental divorce and stroke risk, but only among men and not among women. This current study used a much larger sample of older women and men, providing us with greater statistical power. Our findings advance the body of knowledge by demonstrating that both men and women aged 65 and older in this more recent cohort were significantly at greater risk of stroke when they had a history of parental divorce. We found that the association between parental divorce and stroke was of similar magnitude to two well-established risk factors for stroke: diabetes [41] and major depressive disorder [40]. Possible explanations were discussed, such as biological embedding and the impact of childhood poverty. We discussed how the cohort in question experienced parental divorce before a national increase in the prevalence of divorce and, thus, it is important to consider how other contextual factors, such as community stigma related to divorce and high familial conflict, which may have affected the cohort's health and well-being. Due to the changes in societal norms, it is not clear that Gen X or Millennial Americans will experience a similar link between parental divorce and stroke as was evident in our sample from the Baby Boom and Silent Generation cohorts. Future research is needed to investigate generational differences in the parental divorce-stroke association. No association was found between childhood emotional abuse, parental domestic violence, parental incarceration, parental mental illness, or parental substance use and stroke risk, once a wide range of sociodemographic factors were taken into account. The following factors were found to be associated with stroke incidence in this sample: higher age, non-Hispanic Black ethnicity, male sex, and lower socioeconomic status (measured through education level and household income). Because the association between parental divorce and stroke remained even after controlling for many common risk factors, future research is needed to clarify the potential pathways causing this association.

Supporting information

S1 Table. List of covariates.
(DOCX)

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References

1. Tsao CW, Aday AW, Almarzooq ZI, Anderson CAM, Arora P, Avery CL, et al. Heart disease and stroke statistics—2023 update: a report from the American Heart Association. Circulation. 2023 Feb 21; 147 (8):e93–621. https://doi.org/10.1161/CIR.0000000000001123 PMID: 36695182
2. Correction to: 2024 Heart Disease and Stroke Statistics: A Report of US and Global Data From the American Heart Association [Internet]. [cited 2024 Sep 10]. Available from: https://www.ahajournals.org/doi/epub/10.1161/CIR.0000000000001247
3. Kochanek KD, Murphy SL, Xu J, Arias E. Mortality in the United States, 2022. National Center for Health Statistics. 2024 March [cited 2024 Sept 9]; Data Brief No. 492. Available from: https://www.cdc.gov/nchs/products/databriefs/db492.htm
4. Stephan KM, Pérennou D. Mobility after stroke: relearning to walk. In: Platz T, editor. Clinical pathways in stroke rehabilitation: evidence-based clinical practice recommendations [Internet]. Cham (CH): Springer; 2021 [cited 2024 Jul 18]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK585593/
5. Lindvall E, Franzon K, Lundström E, Kilander L. The impact of stroke on the ability to live an independent life at old age: a community-based cohort study of Swedish men. BMC Geriatrics. 2023 Mar 6; 23 (1):126. https://doi.org/10.1186/s12877-023-03817-1 PMID: 36879184
6. Strilciuc S, Grad DA, Radu C, Chira D, Stan A, Ungureanu M, et al. The economic burden of stroke: a systematic review of cost of illness studies. J Med Life. 2021; 14(5):606–19. https://doi.org/10.25122/jml-2021-0361 PMID: 35027963
7. Martin SS, Aday AW, Almarzooq ZI, Anderson CAM, Arora P, Avery CL, et al. 2024 Heart disease and stroke statistics: a report of US and global data from the American Heart Association. Circulation. 2024 Feb 20; 149(8):e347–913.
8. Gardener H, Sacco RL, Rundek T, Battistella V, Cheung YK, Elkind MSV. Race and ethnic disparities in stroke incidence in the Northern Manhattan Study. Stroke. 2020 Apr; 51(4):1064–9. https://doi.org/10.1161/STROKEAHA.119.028806 PMID: 32078475
9. Wong CW, Kwok CS, Narain A, Gulati M, Mihalidou AS, Wu P, et al. Marital status and risk of cardiovascular diseases: a systematic review and meta-analysis. Heart. 2018 Dec 1; 104(23):1937–48. https://doi.org/10.1136/heartjnl-2018-313005 PMID: 29921571
10. Lindmark A, Eriksson M, Darehed D. Socioeconomic status and stroke severity: understanding indirect effects via risk factors and stroke prevention using innovative statistical methods for mediation analysis. PLoS One. 2022 Jun 24; 17(6):e0270533. https://doi.org/10.1371/journal.pone.0270533 PMID: 35749530
11. Kapral MK, Austin PC, Jeyakumar G, Hall R, Chu A, Khan AM, et al. Rural-urban differences in stroke risk factors, incidence, and mortality in people with and without prior stroke. Circulation: Cardiovascular Quality and Outcomes. 2019 Feb; 12(2):e004973. https://doi.org/10.1161/CIRCOUTCOMES.118.004973 PMID: 30760007
12. Boehme AK, Esenwa C, Elkind MSV. Stroke risk factors, genetics, and prevention. Circ Res. 2017 Feb 3; 120(3):472–95. https://doi.org/10.1161/CIRCRESAHA.116.308398 PMID: 28154098
13. O'Donnell MJ, Chin SL, Rangarajan S, Xavier D, Liu L, Zhang H, et al. Global and regional effects of potentially modifiable risk factors associated with acute stroke in 32 countries (INTERSTROKE): a case-control study. The Lancet. 2016 Aug 20; 388(10046):761–75. https://doi.org/10.1016/S0140-6736(16)30506-2 PMID: 27431356
14. Campbell JA, Walker RJ, Egede LE. Associations between adverse childhood experiences, high-risk behaviors, and morbidity in adulthood. American Journal of Preventive Medicine. 2016 Mar; 50(3):344–52. https://doi.org/10.1016/j.amepre.2015.07.022 PMID: 26474668

15. Schüssler-Fiorenza Rose SM, Snyder MP, Slavich GM. Adverse childhood experiences, diabetes and associated conditions, preventive care practices and health care access: a population-based study. Preventive Medicine: An International Journal Devoted to Practice and Theory. 2022 Jul; 160:1–7. https://doi.org/10.1016/j.ypmed.2022.107044 PMID: 35398366

16. Godoy LC, Frankfurter C, Cooper M, Lay C, Maunder R, Farkouh ME. Association of adverse childhood experiences with cardiovascular disease later in life: a review. JAMA Cardiol. 2021 Feb 1; 6(2):228–35. https://doi.org/10.1001/jamacardio.2020.6050 PMID: 33263716

17. Gomis-Pomares A, Villanueva L, Prado-Gascó V. Does it run in the family? Intergenerational transmission of household dysfunctions. Child & Adolescent Social Work Journal [Internet]. 2021 May 27 [cited 2024 Jul 18]; Available from: https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip, sso&db=psyh&AN=2021-51124-001&site=ehost-live&scope=site&custid=s9775827

18. Swedo EA, Aslam MV, Dahlberg LL, Niolon PH, Guinn AS, Simon TR, et al. Prevalence of adverse childhood experiences among U.S. adults—Behavioral Risk Factor Surveillance System, 2011–2020. MMWR Morb Mortal Wkly Rep. 2023 Jun 30; 72(26):707–15. 1. https://doi.org/10.15585/mmwr.mm7226a2 PMID: 37384554

19. Basu A, McLaughlin KA, Misra S, Koenen KC. Childhood maltreatment and health impact: the examples of cardiovascular disease and type 2 diabetes mellitus in adults. Clinical Psychology: Science and Practice. 2017 Jun; 24(2):125–39. 1. https://doi.org/10.1111/cpsp.12191 PMID: 28867878

20. Draper B, Pfaff JJ, Pirkis J, Snowdon J, Lautenschlager NT, Wilson I, et al. Long-term effects of childhood abuse on the quality of life and health of older people: results from the depression and early prevention of suicide in general practice project. Journal of the American Geriatrics Society. 2008; 56 (2):262–71. 1. https://doi.org/10.1111/j.1532-5415.2007.01537.x PMID: 18031482

21. Rich-Edwards JW, Mason S, Rexrode K, Spiegelman D, Hibert E, Kawachi I, et al. Physical and sexual abuse in childhood as predictors of early onset cardiovascular events in women. Circulation. 2012 Aug 21; 126(8):920–7. 1. https://doi.org/10.1161/CIRCULATIONAHA.111.076877 PMID: 22787111

22. Soares ALG, Hammerton G, Howe LD, Rich-Edwards J, Halligan S, Fraser A. Sex differences in the association between childhood maltreatment and cardiovascular disease in the UK Biobank. Heart. 2020 Sep; 106(17):1310–6. 1. https://doi.org/10.1136/heartjnl-2019-316320 PMID: 32665362

23. Novais M, Henriques T, Vidal-Alves MJ, Magalhães T. When problems only get bigger: The impact of adverse childhood experience on adult health. Frontiers in Psychology. 2021 Jul 14; 12. 1. https://doi.org/10.3389/fpsyg.2021.693420 PMID: 34335410

24. Aksu GG, Kılıçaslan F, Kütük MÖ, Tufan AE, Kayar O, Toros F. Parental attitudes, child mental health problems and gender factor in the divorce process. Cukurova Med J. 2024 Mar 29; 49(1):181–91. 1.

25. Bayaz-Öztürk G. Parental breakup and children's outcomes in the United States. Family Relations. 2022; 71(4):1802–16. 1.

26. Bohman H, Låftman SB, Päären A, Jonsson U. Parental separation in childhood as a risk factor for depression in adulthood: a community-based study of adolescents screened for depression and followed up after 15 years. BMC Psychiatry [Internet]. 2017 Mar 29 [cited 2024 Jul 18]; 17. Available from: https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,sso&db=psyh&AN=2017-14802-001&site=ehost-live&scope=site&custid=s9775827 https://doi.org/10.1186/s12888-017-1252-z PMID: 28356107

27. Fuller-Thomson E, Dalton AD. Suicidal ideation among individuals whose parents have divorced: findings from a representative Canadian community survey. Psychiatry Research. 2011 May 15; 187 (1):150–5. 1. https://doi.org/10.1016/j.psychres.2010.12.004 PMID: 21251718

28. Palmtag EL. Like ripples on a pond: the long-term consequences of parental separation and conflicts in childhood on adult children's self-rated health. SSM Popul Health. 2022 Jun; 18:101100. 1. https://doi.org/10.1016/j.ssmph.2022.101100 PMID: 35493410

29. Varis H, Hagnäs M, Mikkola I, Nordström T, Puukka K, Taanila A, et al. Parental separation and offspring morbidity in adulthood: a descriptive study of the Northern Finland Birth Cohort 1966. Scand J Public Health. 2022 Jul 1; 50(5):601–12. 1. https://doi.org/10.1177/14034948211014296 PMID: 34030537

30. Amiri S, Fathi-Ashtiani M, Sedghijalal A, Fathi-Ashtiani A. Parental divorce and offspring smoking and alcohol use: a systematic review and meta-analysis of observational studies. Journal of addictive diseases. 2021 Mar 2; 39. 1.

31. Fuller-Thomson E, Filippelli J, Lue-Crisostomo CA. Gender-specific association between childhood adversities and smoking in adulthood: findings from a population-based study. Public Health. 2013 May; 127(5):449–60. 1. https://doi.org/10.1016/j.puhe.2013.01.006 PMID: 23465733

32. Jabbour N, Abi Rached V, Haddad C, Salameh P, Sacre H, Hallit R, et al. Association between parental separation and addictions in adolescents: results of a National Lebanese Study. BMC Public Health. 2020 Jun 19; 20(1):965. 1. https://doi.org/10.1186/s12889-020-09108-3 PMID: 32560706

33. Goisis A, Özcan B, Van Kerm P. Do children carry the weight of divorce? Demography. 2019 Jun; 56 (3):785–811. 1. https://doi.org/10.1007/s13524-019-00784-4 PMID: 31187450

34. Ghozy S, Zayan AH, El-Qushayri AE, Parker KE, Varney J, Kallmes KM, et al. Physical activity level and stroke risk in US population: A matched case–control study of 102,578 individuals. Annals of Clinical and Translational Neurology. 2022; 9(3):264–75. 1. https://doi.org/10.1002/acn3.51511 PMID: 35094505

35. Ma LZ, Sun FR, Wang ZT, Tan L, Hou XH, Ou YN, et al. Metabolically healthy obesity and risk of stroke: a meta-analysis of prospective cohort studies. Ann Transl Med. 2021 Feb; 9(3):197. 1. https://doi.org/10.21037/atm-20-4387 PMID: 33708824

36. Patel UK, Dave M, Lekshminarayanan A, Malik P, DeMasi M, Chandramohan S, et al. Risk factors and incidence of acute ischemic stroke: a comparative study between young adults and older adults. Cureus. 13(4):e14670. https://doi.org/10.7759/cureus.14670 PMID: 34055518

37. Petitti DB, Sidney S, Quesenberry C, Bernstein A. Stroke and cocaine or amphetamine use. Epidemiology. 1998 Nov; 9(6):596–600. 1. PMID: 9799166

38. Smyth A, O'Donnell M, Rangarajan S, Hankey GJ, Oveisgharan S, Canavan M, et al. Alcohol intake as a risk factor for acute stroke. Neurology. 2023 Jan 10; 100(2):e142–53. 1.

39. Westover AN, McBride S, Haley RW. Stroke in young adults who abuse amphetamines or cocaine: a population-based study of hospitalized patients. Arch Gen Psychiatry. 2007 Apr; 64(4):495–502. 1. https://doi.org/10.1001/archpsyc.64.4.495 PMID: 17404126

40. Dong JY, Zhang YH, Tong J, Qin LQ. Depression and risk of stroke. Stroke. 2012 Jan; 43(1):32–7. 1.

41. Lau L, Lew J, Borschmann K, Thijs V, Ekinci EI. Prevalence of diabetes and its effects on stroke outcomes: a meta-analysis and literature review. J Diabetes Investig. 2019 May; 10(3):780–92. 1.

42. Fuller-Thomson E, Dalton AD. Gender Differences in the Association between Parental Divorce during Childhood and Stroke in Adulthood: Findings from a Population-Based Survey. International Journal of Stroke. 2015 Aug 1; 10(6):868–75. 1. https://doi.org/10.1111/j.1747-4949.2012.00935.x PMID: 23228186

43. Amemiya A, Fujiwara T, Shirai K, Kondo K, Oksanen T, Pentti J, et al. Association between adverse childhood experiences and adult diseases in older adults: a comparative cross-sectional study in Japan and Finland. BMJ Open. 2019 Aug; 9(8):e024609. https://doi.org/10.1136/bmjopen-2018-024609 PMID: 31446402

44. Centers for Disease Control and Prevention. Behavioral Risk Factor Surveillance System (BRFSS) Questionnaire. Atlanta, Georgia. 2022 [cited 2024 Sept 9]. Available from: https://www.cdc.gov/brfss/annual_data/annual_2022.html

45. Centers for Disease Control and Prevention. Behavioral Risk Factor Surveillance System (BRFSS) Questionnaire. Atlanta, Georgia. 2019 [cited 2024 Sept 9]. Available from: https://www.cdc.gov/brfss/annual_data/annual_2019.html

46. Centers for Disease Control and Prevention. Behavioral Risk Factor Surveillance System (BRFSS) Questionnaire. Atlanta, Georgia. 2023 [cited 2024 Sept 9]. Available from: https://www.cdc.gov/brfss/annual_data/annual_2023.html 1.

47. Langkamp DL, Lehman A, Lemeshow S. Techniques for handling missing data in secondary analyses of large surveys. Acad Pediatr. 2010 May-Jun; 10(3):205–10. https://doi.org/10.1016/j.acap.2010.01.005 Epub 2010 Mar 24. PMID: 20338836; PMCID: PMC2866831.

48. Dodd KE, Blackley DJ, Mazurek JM. Cardiovascular disease among adults with Work-related asthma, 2012–2017. Am J Prev Med. 2023 Feb; 64(2):194–203. 1. https://doi.org/10.1016/j.amepre.2022.09.010 PMID: 36371324

49. Imoisili OE, Chung A, Tong X, Hayes DK, Loustalot F. Prevalence of stroke—Behavioral Risk Factor Surveillance System, United States, 2011–2022. MMWR Morb Mortal Wkly Rep [Internet]. 2024 [cited 2024 Sep 9];73. Available from: https://www.cdc.gov/mmwr/volumes/73/wr/mm7320a1.htm 1.

50. Nagayoshi M, Everson-Rose SA, Iso H, Mosley TH, Rose KM, Lutsey PL. Social network, social support, and risk of incident stroke: the atherosclerosis risk in communities study. Stroke. 2014 Oct; 45 (10):2868–73. 1.

51. Ford CD, Gray MS, Crowther MR, Wadley VG, Austin AL, Crowe MG, et al. Depressive symptoms and risk of stroke in a national cohort of Black and white participants from REGARDS. Neurology Clinical Practice. 2021 Aug; 11(4):e454–61. 1. https://doi.org/10.1212/CPJ.0000000000000983 PMID: 34484944

52. Khan AI, Abuzainah B, Gutlapalli SD, Chaudhuri D, Khan KI, Al Shouli R, et al. Effect of major depressive disorder on stroke risk and mortality: a systematic review. Cureus. 15(6):e40475. 1. https://doi.org/10.7759/cureus.40475 PMID: 37456466

53. Bloomgarden Z, Chilton R. Diabetes and stroke: an important complication. J Diabetes. 2021 Mar; 13 (3):184–90. 1. https://doi.org/10.1111/1753-0407.13142 PMID: 33300237

54. van Sloten TT, Sedaghat S, Carnethon MR, Launer LJ, Stehouwer CDA. Cerebral microvascular complications of type 2 diabetes: stroke, cognitive dysfunction, and depression. The Lancet Diabetes & Endocrinology. 2020 Apr 1; 8(4):325–36. 1. https://doi.org/10.1016/S2213-8587(19)30405-X PMID: 32135131

55. Tun NN, Arunagirinathan G, Munshi SK, Pappachan JM. Diabetes mellitus and stroke: a clinical update. World J Diabetes. 2017 Jun 15; 8(6):235–48. 1. https://doi.org/10.4239/wjd.v8.i6.235 PMID: 28694925

56. Tullius JM, De Kroon MLA, Almansa J, Reijneveld SA. Adolescents' mental health problems increase after parental divorce, not before, and persist until adulthood: a longitudinal TRAILS study. Eur Child Adolesc Psychiatry. 2022 Jun 1; 31(6):969–78. 1. https://doi.org/10.1007/s00787-020-01715-0 PMID: 33566187

57. Obeid S, Al Karaki G, Haddad C, Sacre H, Soufia M, Hallit R, et al. Association between parental divorce and mental health outcomes among Lebanese adolescents: results of a national study. BMC Pediatr. 2021 Oct 18; 21(1):455. 1. https://doi.org/10.1186/s12887-021-02926-3 PMID: 34657599

58. Snyder-Mackler N, Snyder-Mackler L. Holistic Rehabilitation: Biological embedding of social adversity and its health implications. Physical Therapy. 2022 Jan 1; 102(1):pzab245. 1. https://doi.org/10.1093/ptj/pzab245 PMID: 34718801

59. Berens AE, Jensen SKG, Nelson CA. Biological embedding of childhood adversity: from physiological mechanisms to clinical implications. BMC Med. 2017 Jul 20; 15(1):135. 1. https://doi.org/10.1186/s12916-017-0895-4 PMID: 28724431

60. Leistner C, Menke A. Chapter 4—Hypothalamic–pituitary–adrenal axis and stress. In: Lanzenberger R, Kranz GS, Savic I, editors. Handbook of clinical neurology [Internet]. Elsevier; 2020 [cited 2024 Jul 25]. p. 55–64. (Sex Differences in Neurology and Psychiatry; vol. 175). Available from: https://www.sciencedirect.com/science/article/pii/B9780444641236000047 1.

61. Lovallo WR. Early life adversity reduces stress reactivity and enhances impulsive behavior: implications for health behaviors. Int J Psychophysiol. 2013 Oct; 90(1): https://doi.org/10.1016/j.ijpsycho.2012.10.006 1. PMID: 23085387

62. Degroote C, von Känel R, Thomas L, Zuccarella-Hackl C, Messerli-Bürgy N, Saner H, et al. Lower diurnal HPA-axis activity in male hypertensive and coronary heart disease patients predicts future CHD risk. Front Endocrinol [Internet]. 2023 Mar 10 [cited 2024 Jul 25]; 14. Available from: https://www.frontiersin.org/journals/endocrinology/articles/10.3389/fendo.2023.1080938/full 1. https://doi.org/10.3389/fendo.2023.1080938 PMID: 36967749

63. Keller J, Gomez R, Williams G, Lembke A, Lazzeroni L, Murphy GM, et al. HPA axis in major depression: cortisol, clinical symptomatology, and genetic variation predict cognition. Mol Psychiatry. 2017 Apr; 22(4):527–36. 1. https://doi.org/10.1038/mp.2016.120 PMID: 27528460

64. Booth J, Connelly L, Lawrence M, Chalmers C, Joice S, Becker C, et al. Evidence of perceived psychosocial stress as a risk factor for stroke in adults: a meta-analysis. BMC Neurol. 2015 Nov 12; 15:233. 1. https://doi.org/10.1186/s12883-015-0456-4 PMID: 26563170

65. Chen XG, Shi SY, Hu L, Chen Y, Sun HW, Zhou L, et al. Longitudinal changes in the hypothalamic–pituitary–adrenal axis and sympathetic nervous system are related to the prognosis of stroke. Frontiers in Neurology. 2022 Jul 27; 13:946593. 1.

66. Kim S, Park ES, Chen PR, Kim E. Dysregulated hypothalamic–pituitary–adrenal axis is associated with increased inflammation and worse outcomes after ischemic stroke in diabetic mice. Frontiers in Immunology [Internet]. 2022 [cited 2024 Jul 25]; 13. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9243263/ 1. https://doi.org/10.3389/fimmu.2022.864858 PMID: 35784349

67. Stannard S, Berrington A, Alwan NA. The mediating pathways between parental separation in childhood and offspring hypertension at midlife. Sci Rep. 2022 Apr 29; 12(1):7062. 1. https://doi.org/10.1038/s41598-022-11007-z PMID: 35488035

68. Hepburn M, Bollu PC, French B, Sahota P. Sleep medicine: stroke and sleep. Mo Med. 2018; 115 (6):527–32. 1. PMID: 30643347

69. Turunen J, Norell-Clarke A, Hagquist C. How do children and adolescents of separated parents sleep? An investigation of custody arrangements, sleep habits, sleep problems, and sleep duration in Sweden. Sleep Health. 2021 Dec; 7(6):716–22. 1. https://doi.org/10.1016/j.sleh.2021.06.002 PMID: 34413000

70. Desch J, Bakour C, Mansuri F, Tran D, Schwartz S. The association between adverse childhood experiences and insomnia symptoms from adolescence to adulthood: evidence from the Add Health study. Sleep Health. 2023 Oct 1; 9(5):646–53. 1. https://doi.org/10.1016/j.sleh.2023.06.001 PMID: 37419708

71. Coulter R, Thomas M. A new look at the housing antecedents of separation. Demographic Research. 2019; 40:725–60. 1.

72. Karney BR, Wenger JB, Zaber MA, Bradbury TN. State minimum wage increases delay marriage and reduce divorce among low-wage households. Journal of Marriage and Family. 2022; 84(4):1196–207. 1. https://doi.org/10.1111/jomf.12832 PMID: 36245674

73. Bonnet C, Solaz A. Does parental separation increase the risk of child poverty? Population Societies. 2023 Apr 19; 610(4):1–4. 1.

74. Hauser R, Burkhauser RV, Couch KA, Bayaz-Ozturk G. Wife or Frau, women still do worse: a comparison of men and women in the United States and Germany after union dissolutions in the 1990s and 2000s. Working Papers [Internet]. 2016 Dec [cited 2024 Jul 25]; Available from: https://ideas.repec.org//p/uct/uconnp/2016-39.html 1.

75. Hogendoorn B, Leopold T, Bol T. Divorce and diverging poverty rates: a risk-and-vulnerability approach. Journal of Marriage and Family. 2020; 82(3):1089–109. 1.

76. Leopold T. Gender differences in the consequences of divorce: a study of multiple outcomes. Demography. 2018 Jun; 55(3):769–97. 1. https://doi.org/10.1007/s13524-018-0667-6 PMID: 29654601

77. Chaudry A, Wimer C. Poverty is not just an indicator: the relationship between income, poverty, and child well-being. Academic Pediatrics. 2016 Apr 1; 16(3):S23–9. 1. https://doi.org/10.1016/j.acap.2015.12.010 PMID: 27044698

78. Johnson LE, Parra LA, Ugarte E, Weissman DG, Han SG, Robins RW, et al. Patterns of poverty across adolescence predict salivary cortisol stress responses in Mexican-origin youths. Psychoneuroendocrinology. 2021 Oct 1; 132:105340. 1. https://doi.org/10.1016/j.psyneuen.2021.105340 PMID: 34246154

79. Wang J, Geng L. Effects of socioeconomic status on physical and psychological health: lifestyle as a mediator. Int J Environ Res Public Health. 2019 Jan; 16(2):281. 1. https://doi.org/10.3390/ijerph16020281 PMID: 30669511

80. Bardugo A, Bendor CD, Libruder C, Lutski M, Zucker I, Tsur AM, et al. Cognitive function in adolescence and the risk of early-onset stroke. J Epidemiol Community Health [Internet]. 2024 May 23 [cited 2024 Jul 26]; Available from: https://jech.bmj.com/content/early/2024/05/23/jech-2024-222114 1. https://doi.org/10.1136/jech-2024-222114 PMID: 38937113

81. Marshall IJ, Wang Y, Crichton S, McKevitt C, Rudd AG, Wolfe CDA. The effects of socioeconomic status on stroke risk and outcomes. The Lancet Neurology. 2015 Dec; 14(12):1206–18. 1. https://doi.org/10.1016/S1474-4422(15)00200-8 PMID: 26581971

82. McHutchison CA, Backhouse EV, Cvoro V, Shenkin SD, Wardlaw JM. Education, socioeconomic status, and intelligence in childhood and stroke risk in later life: a meta-analysis. Epidemiology. 2017 Jul; 28(4):608–18. 1. https://doi.org/10.1097/EDE.0000000000000675 PMID: 28410350

83. Wan B, Ma N, Zhou Z, Lu W. Modifiable risk factors that mediate the effect of educational attainment on the risk of stroke: a network Mendelian randomization study. Molecular Brain. 2023 May 11; 16(1):39. 1. https://doi.org/10.1186/s13041-023-01030-0 PMID: 37170327

84. Miao L, Yang S, Yi Y, Tian P, He L. Research on the prediction of longevity from both individual and family perspectives. PLoS One. 2022 Feb 18; 17(2):e0263992. 1. https://doi.org/10.1371/journal.pone.0263992 PMID: 35180255

85. Holt-Lunstad J, Smith TB, Layton JB. Social relationships and mortality risk: a meta-analytic review. PLoS Medicine. 2010 Jul 27; 7(7):e1000316. 1.

86. Ahrenfeldt LJ, Möller S, Hvidt NC, Lindahl-Jacobsen R. Religiousness and lifestyle among Europeans in SHARE. Public Health. 2018 Dec 1; 165:74–81. 1. https://doi.org/10.1016/j.puhe.2018.09.009 PMID: 30384031

87. Gough AR. Community property and family law: the family law act of 1969. 1970. Cal Law Trends and Developments; 1(10)

88. National Center for Health Statistics (U.S.). Division of Health Resources Statistics. Advance report of final divorce statistics, 1983. 1985 [cited 2024 Sept 9]; Report V. 34, No. 9, suppl. Available from: https://www.cdc.gov/nchs/products/databriefs/db492.htm

89. National Center for Health Statistics (U.S.) Division of Vital Statistics. Births, marriages, divorces, and deaths: provisional data from February 1999. 2000 Mar 9 [cited 2024 Sept 9]; Report V. 48, No. 2. Available from: https://stacks.cdc.gov/view/cdc/85486 1.

90. Demir-Dagdas T. Parental divorce, parent–child ties, and health: explaining long-term age differences in vulnerability. Marriage & Family Review. 2021 Jan 2; 57(1):24–42. 1.

91. Elam KK, Sandler I, Wolchik S, Tein JY. Non-residential father–child involvement, interparental conflict and mental health of children following divorce: a person-focused approach. J Youth Adolescence. 2016 Mar 1; 45(3):581–93. 1. https://doi.org/10.1007/s10964-015-0399-5 PMID: 26692236

92. O'Mahony PG, Dobson R, Rodgers H, James OFW, Thomson RG. Validation of a population screening questionnaire to assess prevalence of stroke. Stroke. 1995 Aug; 26(8):1334–7. 1. https://doi.org/10.1161/01.str.26.8.1334 PMID: 7631332

93. Moskalenko MI, Ponomarenko IV, Polonikov AV, Zhernakova NI, Efremova OA, Churnosov MI. The role of the stress factor in mediating the genetic predisposition to stroke of the background of hypertensive disease. Neuroscience and Behavioral Physiology. 2020 Feb; 50(2):143–8. 1.

94. Reddy V, Wurtz M, Patel SH, McCarthy M, Raval AP. Oral contraceptives and stroke: foes or friends. Frontiers in Neuroendocrinology. 2022 Oct 1; 67:101016. 1. https://doi.org/10.1016/j.yfrne.2022.101016 PMID: 35870646

95. Gupta HV, Farrell AM, Mittal MK. Transient ischemic attacks: predictability of future ischemic stroke or transient ischemic attack events. Therapeutics and Clinical Risk Management. 2014; 10:27. 1.

96. Prospective Studies Collaboration, Lewington S, Whitlock G, Clarke R, Sherliker P, Emberson J, et al. Blood cholesterol and vascular mortality by age, sex, and blood pressure: a meta-analysis of individual data from 61 prospective studies with 55,000 vascular deaths. Lancet. 2007 Dec 1; 370(9602):1829–39. 1. https://doi.org/10.1016/S0140-6736(07)61778-4 PMID: 18061058

97. You HS, Shin SJ, Kim J, Kang HT. Association between polycythemia and risk of ischemic stroke in males based on the national health insurance service-health screening cohort. Expert Review of Hematology. 2023 Jul 3; 16(7):553–9. https://doi.org/10.1080/17474086.2023.2218610 PMID: 37249134