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Association and pathways of birth in the stroke belt on old age dementia and stroke Mortality *,**

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ABSTRACT

This paper uses data from the Diet and Health Study (DHS) to examine associations between being born in a "stroke belt" state and old age stroke and mortality outcomes. Adding to prior work that used administrative data, our paper explores educational and health mechanisms that are both stratified by geography and by mortality outcomes. Using logistic regression, we first replicate earlier findings of elevation in risk of dementia mortality (OR 1.13, CI [1.07, 1.20]) and stroke mortality (OR 1.17, CI [1.07, 1.29]) for white individuals born in a stroke belt state. These associations are largely unaffected by controls for educational attainment or by experiences with surviving a stroke and are somewhat attenuated by controls for self-rated health status in old age. The results suggest a need to consider additional life course mechanisms in order to understand the persistent effects of place of birth on old age mortality patterns.

Background

Geographic disparities in health and mortality in later life are outlined in a vast and comprehensive literature. While life expectancy has consistently improved through the decades, a gap still exists across different states throughout the United States (Wilmoth, Boe, & Barbieri, 2010). Much of the research done on geographic disparities in health has exclusively focused on individual level factors, but contextual factors have recently gained more momentum as key determinants of population health (Hall, Moonesinghe, Bouye, & Penman-Aguilar, 2019;

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Hamad, Rehkopf, Kuan, & Cullen, 2016). Recent examples include how place of birth is connected with later development of chronic illnesses in life such as cancer (Datta, Glymour, Kosheleva, & Chen, 2012), diabetes (Patton, Benjamin, Kosheleva, Curtis, & Glymour, 2011), cardiovascular disease (Rehkopf et al., 2015), and stroke (Glymour, Kosheleva, & Boden-Albala, 2009) and mortality (Xu et al., 2020). Yet, how contextual factors truly factor into population health are not fully understood, especially early environmental factors and their impact on mortality.

Theories behind life course research state that health disparities in later life could be the result of place-based exposures that occur throughout the lifespan, rather than contemporaneous ones (Lynch & Smith, 2005). The accumulating impact of these life experiences can potentially influence a myriad of different outcomes and how they relate to health in older age (Gustafsson, Hammarström, & San Sebastian, 2015). Moreover, how these life experiences accrue into old age and shape later outcomes are delivered through numerous mechanisms, including educational systems and policy contexts (Gustafsson et al., 2015; Montez & Hayward, 2011).

Migration is a key mechanism that differentiates, while also connecting, past and present place-based exposures. This is due to about a third or more of the United States population residing in a state that they were not born in (Molloy, Smith, & Wozinak, 2011). Thus, a large proportion of place-based disparities found in old age could be linked to exposures in early life that are disparate from those later on. However, standard estimates of mortality often are looked at regarding place of residence in later life, around the time of death, with little to no attention given to early life. Therefore, it is critical to look at the relationship between both contextual exposures in early life and later life when examining health outcomes in later life.

Previous research has looked into the effects that environmental conditions and place have had on the health of older adults, with great focus along the lines of socioeconomic status (Merkin, Karlamangla, Roux, Shrager, & Seeman, 2014; Phelan, Link, & Tehranifar, 2010). Studies that have specifically looked at the effects of state of residence on health outcomes have consistently looked at other predictors, such as social structure, income distribution, and policies (Montez, Hayward, & Wolf, 2017; Montez, Zajacova, & Hayward, 2016). On the other hand, state of birth has typically been utilized to examine early life outcomes of individuals. For example, research has examined how some targeted economic policies are implemented to assist with poverty reduction at the local level and the improvement of healthcare coverage, which in turn improve outcomes such as birth weight (Brown et al., 2019; Komro, Burris, & Wagenaar, 2014: Komro, Livingston, Markowitz, & Wagenaar, 2016). However, these outcomes in early life have the potential to compound over time and have long lasting impacts in both childhood and adulthood (Dhamija, 2018; Haas, 2007; Venkataramani, 2012). Furthermore, other than health outcomes, these consistent exposures have impacts on factors such as learning, employment, and earning power, which all have the potential to influence health (Jürges, 2013).

Some specific health outcomes that people are likely to encounter in later life include conditions such as dementia and stroke. Both of which are among the top leading causes of death within the United States (Xu et al., 2020). Dementia is a debilitating disease which shortens life expectancy, effects memory, and is a key cause of lower quality of life to older adults (Rhodius-Meester et al., 2018). An advanced form of dementia is Alzheimer's disease, which primarily afflicts individuals in later life, as the disease, like many chronic conditions, is associated with an increase in age (McKhann et al., 2011; Yang, 2008). A stroke also is a devastating condition that predominantly impact older adults. Moreover, they are conditions that individuals can experience for a prolonged period or multiple instances before death (Crimmins, Zhang, Kim, & Levine, 2019). This could likely be a result of place-based environmental exposures that people experience throughout the life course, which may accumulate across time and result in repeated instances of poor health, including multiple instances of stroke. Dementia and stroke both can be heavily influenced by a myriad of different mechanisms that heighten

the risk. Such mechanisms include education (Addo et al., 2012; Sando et al., 2008), income (Yan et al., 2013), and neighborhood settings (Brown et al., 2013).

In particular, education has been linked with cognition, cognitive decline and associated mortality outcomes, leading to the idea that cognitive reserve, or the ability to tolerate age-related changes and disease related pathology in the brain without developing symptoms (Fratiglioni & Wang, 2007; Meng & D'Arcy, 2012), could be an important factor linking early life geography and associated schooling experiences with later life health and mortality outcomes. Specifically, Meng and D'Arcy (2012) has postulated that cognitive reserve works through both protective and compensatory mechanisms, and that individuals with higher levels have lower prevalence of dementia and Alzheimer's disease. Unfortunately, few analyses have been able to explore links among place, educational attainment, and old age dementia and associated outcomes.¹

Despite these outlined mechanisms, few studies have directly examined the role of an individual's place of birth with their early life environments in predicting mortality in later life. Specifically, there are specific regions of the United States that are known for their poor health outcomes and are aptly named after the diseases that afflict them the greatest, such as a cancer belt or the stroke belt (Blackley, Zheng, & Ketchum, 2012.; Glymour et al., 2009). Concerning the latter, the stroke belt is an area primarily in the South Central and South Atlantic states, where the highest rates of stroke mortality are concentrated (Howard & Howard, 2020; Liao, Greenlund, Croft, Kennan, & Giles, 2009; Lnaska & Kuller, 1995). Even within the last fifty years, stroke mortality in these regions and the United States as a whole has decreased significantly, but this area still retains high levels of mortality (Howard & Howard, 2020).

Furthermore, adult residence in the stroke belt has been researched extensively, highlighting increased risks to many conditions other than stroke, such as hypertension, diabetes, and dementia (Avila-Roger et al., 2020; Gilsanz, Mayeda, Glymour, Quesenberry, & Whitmer, 2017; Howard et al., 2010; Wadley et al., 2011). Some studies have looked at early life residence in the stroke belt as well and found that it is associated with poor outcomes later on, regardless if they continue to reside there in later life or not (Glymour, Kosheleva, Wadley, Weiss, & Manly, 2011; Howard et al., 2013). Additionally, increased risk of stroke can reflect a clustering of cerebrovascular risk factors, which are potential predictors of dementia (Gilsanz et al., 2017). Therefore, there is a fundamental need to examine how birth and residence in later life in the stroke belt jointly influence health outcomes that relate to dementia, both in terms of all-cause mortality and specifically Alzheimer's, and also stroke.

This study seeks to reproduce previous work done by others who have studied the stroke belt (Glymour et al., 2011). However, this analysis is unique from others because we take advantage of our large set of individual level data. Other studies often either have smaller samples, data restricted to an individual state, or aggregate vital statistics data (Glymour et al., 2009; Howard et al., 2013; Howard & Howard, 2020). While there are a few caveats to our data source, mainly with regards to non-white populations (which shall be addressed as one of our limitations later), our unique data still allows us to build on previous work that incorporated smaller datasets or those only with vital statistics data (Glymour et al., 2009; Howard et al., 2013). This is because studies using aggregate data are unable to adjust for factors such as education or other individual level characteristics because the data are grouped into categories such as those based on age, sex, and place. Moreover, of studies specifically done on the stroke belt, some have used a measure of either self-reported stroke or stroke belt birth (Glymour et al., 2009; Wadley et al., 2011), but none have included both together.

This paper addresses the following: (1) whether stroke belt birth is

 $^{^{1}}$ Gilsanz et al. (2017) is an exception that examines the effects of place of birth but the data contains residents from a single state.

associated with late life mortality in terms of dementia, AD, and/or stroke; (2) whether stroke belt residence affects this association; (3) whether these associations differ by race and ethnicity; (4) whether controls for educational attainment, self-rated health status, and selfreported stroke appear to be pathways linking early life and mortality. Ultimately, the aim of this paper is to increase the understanding of the specific determinants of health outcomes and how early environments play a role in them across the life course.

Methods

Data

The data utilized in this study comes from the NIH-AARP Diet and Health Study (DHS). The DHS is a large prospective cohort from members of the American Association of Retired Persons (AARP), ranging from individuals who are 50-71 years old and responded to a mailed questionnaire from 1995 to 1996 (Schatzkin et al., 2001). 3.5 million members of the AARP were initially mailed the survey, which resulted in over 620,000 responses. From these responses, nearly 570,000 provided information that was useable for analysis. The participants from this study were from six states (California, Florida, Louisiana, New Jersey, North Carolina, and Pennsylvania), and two cities (Atlanta, Georgia, and Detroit, Michigan), who provided their written and informed consent. At baseline, the DHS asked a comprehensive questionnaire which measured lifestyle factors and diet of the participants. Also, the questionnaire collected information on nutrition, along with health questions, illness history, and other health-related conditions. Demographic information was collected from participants as well, such race/ethnicity, sex, and educational attainment, along with other variables commonly used to measure health outcomes and well-being.

This data source is distinct due to the large sample size, which is essential to measure rare health outcomes such as dementia and stroke. Furthermore, it is necessary to have large sample sizes in order to properly look at variation at the state-level. Other sources of data, such as the Health and Retirement Study, include the variables laid out in this study, but are somewhat limited, due to the much smaller number of cases that exist regarding the outcomes we are looking at in this study (Sonnega et al., 2014).

We initially began with a sample of 566,397 respondents in the original study, yet specific observations were dropped. First, from this initial sample, 165,917 cases were dropped due to them having invalid states of birth, or those who were born in United States territories and insular regions, and those with missing values. Regarding the latter, the missing causes were due to the observations not having social security numbers, which prevent state of birth identification. Next, a further 46,908 observations were dropped so that the sample consists of individuals who are of the age 55 and older. Thus, the final sample that was used for analysis was 353,572.

Measures

Mortality. The key outcomes in this study are self-reported (non-fatal) stroke and three different types of mortality: all-cause dementia, Alz-heimer's Disease (AD), and stroke. All forms of death are ascertained from the follow-up of the DHS. The vital status of the individual refers to whether they are deceased or not and was obtained by the annual linkage of the members of the cohort in the DHS to the Master Death Files of the Social Security Administration (Etemadi et al., 2017) between 1995 and 2011. Cause of death information was then followed up with searches of the National Death Index, focused on death from the particular cause, and corresponding International Classification of Disease (ICD) Codes.

Stroke Belt Birth. Stroke belt birth was created by using the first three digits of the individual social security number of each in the cohort (asked in the initial survey), allowing the information of the state to be

identified (Fletcher, 2015). From that, it was separated into the states that did or did not fall into the stroke belt. Stroke belt constitutes the 11 states that have that historically had the highest mortality rates from stroke: Alabama, Arkansas, Georgia, Indiana, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia (Liao et al., 2009).

Stroke Belt Residence. Stroke belt residence was ascertained from the original survey, for it asked the participants which state they lived in at the time. The eight states of residence from this study are: California, Florida, Georgia, Louisiana, Michigan, New Jersey, North Carolina, and Pennsylvania. Like with the stroke belt birth variable, those states that are included which fall into the stroke belt were counted for the residence variable.

Covariates. Race and ethnicity were used to account for the differential risk that exists along the boundaries of race and ethnicity in health. Specifically, it was separated into the categories of white and non-white. Likewise, Sex was used as a variable to control for the difference in mortality risk between men and women. Educational attainment levels (less than high school, high school, some college, and college grade or more) were included to account for the influence that schooling provides throughout the life course with regard to health outcomes. Age was utilized to see the trends in older individuals, and how it impacts health across the life course. Also, we control for age-squared in the event that there is a non-linear relationship that exists with the death outcomes. Finally, self-rated health was included as a control, as it has been shown as a valid predictor of health outcomes (Jylhä, 2009; Schnittker & Bacak, 2014).

Analytic strategy

We used logistic regression to estimate the race-stratified odds ratios for the specific causes of mortality laid out in this study for those born in the stroke belt and those who reside in the stroke belt. First, the odds ratios were calculated for those who were born in the stroke belt. Following this, the same was done for those who resided in the stroke belt at the time of death. After examining these results in separate models, logistic regressions concurrently adjusting for both state of residence and state of birth.

The three tables of results in the series includes the aforementioned modeling of state of birth and state of residence individually and together. In the first set of results, we control for sex, age, and agesquared. The second table of results then introduces the control of educational attainment. Then, the third set of results also controls for the variable of self-rated health. After these sets of results, we then opt to statistically test whether racial groups differ in our estimated effects of state of birth. This is done by pooling together both the white and nonwhite racial groups together and adding an interaction term for nonwhites and place of birth, first with all controls, and then one without the measure of self-rated health.

Results

Descriptive statistics of the study sample are presented in Table 1. Of the 353,572 observations in the sample, all fifty U.S. states are accounted for in the stroke belt birth variable, while eight states made up the stroke belt residence. Approximately 12.08% (42,697) of our sample was born in the stroke belt, whereas 14.81% (52,354) resided in the stroke belt at the time of death (Table 1). The average age was 63.32 (SD 4.53) years old, and the sample was 37.64% (113,069) female. Over 90% of the individuals were non-Hispanic white, with those were not non-Hispanic whites accounting for 6.59% (23,309). For the three causes of death used in this study, there were 10,247 deaths from all forms of dementia, 1486 deaths from Alzheimer's disease, and 4204 deaths from stroke. Table 2 presents a cross tabulation between stroke belt birthplace and stroke belt residence and shows the large number of cases we have available in each cell for our analysis. Table 3 stratifies the

Table 1

Descriptive statistics (N = 353,572).

	Ν	% (Mean; SD)
Dependent variables		
All Cause Dementia Death (%)	10,247	2.90
Alzheimer's Disease Death (%)	1486	0.42
Stroke Death (%)	4204	1.12
Self-Reported (Non-Fatal) Stroke (%)	8394	2.37
Independent variables		
Stroke Belt Birth (%)	42,697	12.08
Stroke Belt Residence (%)	52,354	14.81
Other variables		
Age (55–72)		(63.32; 4.53)
Self-Rated Health (1–5)		(2.46; 0.96)
Female (%)	133,069	37.64
Non-White (%)	23,309	6.59
Education		
<hs (%)<="" td=""><td>20,646</td><td>5.84</td></hs>	20,646	5.84
Completed high school (%)	101,626	28.74
Some college (%)	80,672	22.82
College graduate + (%)	142,298	40.25
Missing (%)	8330	2.36

Table 2

Cross-tabulation of stroke belt birth and residence (N = 353,752).

Stroke Belt Birth	Stroke Belt Residen			
	Non-Stroke Belt	Stroke Belt	Total	
Non-Stroke Belt Stroke Belt Total	289,358 (96.1%) 11,860 (3.9%) 301,218 (100%)	21,517 (41.1%) 30,837 (58.9%) 52,354 (100%)	310,875 (87.9%) 42,697 (12.1%) 353,572 (100%)	

Table 3

Cross-tabulation of stroke belt birth and residence, by white and non-white populations (N = 353,752).

Stroke Belt Birth	Stroke Belt Residen			
	Non-Stroke Belt	Stroke Belt	Total	
White population				
Non-Stroke Belt	271,295 (96.4%)	20,475 (41.8%)	291,770 (88.3%)	
Stroke Belt	10,010 (3.6%)	28,483 (58.2%)	38,493 (11.7%)	
Total	281,305	48,958	330,263	
Non-White population	(100%)	(100%)	(100%)	
Non-Stroke Belt	18,063 (90.7%)	1042 (30.7%)	19,105 (82.0%)	
Stroke Belt	1850 (9.3%)	2354 (69.3%)	4204 (18.0%)	
Total	19,913 (100%)	3396 (100%)	23,309 (100%)	

cross tabulation by race (white vs. non-white), which anticipates later results of relatively imprecise estimates for non-white respondents.

Table 4 shows odds ratios of cause-specific mortality, adjusted for age, age-squared, and sex. The results first modeled birth and residence

separately, and then modeled the two together for the final results. For whites, stroke belt birth was an important predictor of all four causes of mortality for whites, showing higher odds of death from all-cause dementia (OR = 1.13; 1.07–1.20), Alzheimer's disease (OR = 1.21; 1.04–1.41), stroke (OR = 1.17; 1.07–1.29) or self-reported stroke (OR = 1.19; 1.12–1.27), respectively. Non-whites only saw stroke belt birth as a significant predictor of all-cause dementia (OR = 1.24; 1.01–1.52) and self-reported stroke (OR = 1.23; 1.01–1.49). The lack of effects for Alzheimer's disease stroke mortality contrasts with the findings in Glymour et al., 2011, though that paper explores older individuals than our study population.

Stroke belt residence was associated with 17% higher odds in all cause dementia (OR = 1.17; 1.11–1.23) and Alzheimer's disease (OR = 1.17; 1.01–1.35) in whites and higher odds for self-reported stroke (OR = 1.11; 1.04–1.18), while non-whites were significantly associated with all-cause dementia (OR = 1.30; 1.04–1.62) and self-reported stroke (OR = 1.24; 1.01–1.54). Modeled together, stroke belt residence and stroke belt birth saw no significant association only between stroke belt birth and stroke mortality (OR = 1.22; 1.08–1.38) and self-reported stroke (OR = 1.18; 1.08–1.29), with self-reported stroke seeing the highest level of significance. For stroke belt residence, the only significant association was with all-cause dementia (OR = 1.15; 1.07–1.23). Appendix Table 1 pools the results and includes interactions to show that we cannot detect statistical differences in the results by white/non-white status.

Tables 5-7 explore whether the associations of stroke belt birth and residence with mortality are explained by education, self-rated health, and self-rated stroke sequentially. Table 5 mirrors the previous model but adds the additional control of education. Following the results in Gilsanz et al. (2017) but expanding the analysis to a national sample, we find a limited mediating effect of education. The results in Table 4 are largely unchanged, although there is some reduction in statistical significance. Table 6 emulates the initial model, but opts to control for self-rated health. Controlling for self-rated health status leads to modest attenuation in the stroke belt effects for mortality outcomes. This is not surprising due to the fact that a self-rated health measure would likely take into account previous stroke occurrences, thus resulting in the lessening of the stroke belt effects. Table 7 emulates prior models as well, but controls for self-reported (non-fatal) stroke in predicting mortality outcomes. Interestingly, we find very little changes from the original findings, suggesting the mechanisms linking the "stroke belt" with later mortality operate through broader channels than through experiences with stroke.

Discussion

Previous research has made noteworthy contributions to the literature concerning place-based disparities in mortality. Despite this, much

Table 4

Age and sex adjusted odds ratios for cause-specific mortality, by race and stroke belt birth/residence (ages 55 and over).

Outcomes	Birth and Resid	lence Modeled Separ	ately		Birth and Residence Modeled Together			
	Stroke Belt Birth		Stroke Belt Residence		Stroke Belt Birth		Stroke Belt Residence	
	Odds Ratio	95% CI	Odds Ratio	95% CI	Odds Ratio	95% CI	Odds Ratio	95% CI
White population								
All Cause Dementia	1.13***	(1.07, 1.20)	1.17***	(1.11, 1.23)	1.03	(0.96, 1.12)	1.15***	(1.07, 1.23)
Alzheimer's Disease	1.21**	(1.04, 1.41)	1.17**	(1.01, 1.35)	1.15	(0.94, 1.40)	1.08	(0.90, 1.30)
Stroke	1.17**	(1.07, 1.29)	1.06	(0.97, 1.15)	1.22**	(1.08, 1.38)	0.94	(0.84, 1.05)
Self-Reported Stroke	1.19***	(1.12, 1.27)	1.11***	(1.04, 1.18)	1.18***	(1.08, 1.29)	1.01	(0.94, 1.10)
Non-white population								
All Cause Dementia	1.24**	(1.01, 1.52)	1.30**	(1.04, 1.62)	1.12	(0.88, 1.45)	1.21	(0.92, 1.58)
Alzheimer's Disease	0.90	(0.46, 1.76)	1.01	(0.50, 2.06)	0.85	(0.38, 1.90)	1.12	(0.48, 2.60)
Stroke	1.08	(0.80, 1.46)	0.84	(0.59, 1.21)	1.24	(0.86, 1.77)	0.74	(0.48, 1.13)
Self-Reported Stroke	1.23**	(1.01, 1.49)	1.24*	(1.01, 1.54)	1.15	(0.91, 1.45)	1.15	(0.89, 1.48)

p < 0.05, p < 0.01, p < 0.001, p < 0.001.

Table 5

Age, and adjusted odds ratios for cause-specific mortality, by race and stroke belt birth/residence (ages 55 and over), controlling for education.

Outcomes	Birth and Residence Modeled Separately				Birth and Residence Modeled Together			
	Stroke Belt Birth		Stroke Belt Residence		Stroke Belt Birth		Stroke Belt Residence	
	Odds Ratio	95% CI	Odds Ratio	95% CI	Odds Ratio	95% CI	Odds Ratio	95% CI
White population								
All Cause Dementia	1.13***	(1.06, 1.20)	1.17***	(1.11, 1.23)	1.02	(0.95, 1.10)	1.15***	(1.08, 1.24)
Alzheimer's Disease	1.21*	(1.03, 1.41)	1.16*	(1.01, 1.34)	1.15	(0.94, 1.40)	1.08	(0.90, 1.30)
Stroke	1.17**	(1.06, 1.28)	1.06	(0.97, 1.15)	1.21**	(1.07, 1.36)	0.95	(0.85, 1.06)
Self-Reported Stroke	1.17***	(1.09, 1.25)	1.12***	(1.04, 1.19)	1.14**	(1.04, 1.24)	1.04	(0.96, 1.12)
Non-white population								
All Cause Dementia	1.22	(0.99, 1.50)	1.29*	(1.03, 1.61)	1.11	(0.86, 1.42)	1.21	(0.92, 1.59)
Alzheimer's Disease	0.91	(0.46, 1.79)	1.03	(0.51, 2.09)	0.86	(0.38, 1.92)	1.13	(0.48, 2.63)
Stroke	1.06	(0.78, 1.43)	0.84	(0.58, 1.20)	1.22	(0.85, 1.74)	0.74	(0.48, 1.14)
Self-Reported Stroke	1.19	(0.98, 1.45)	1.23	(1.00, 1.52)	1.11	(0.87, 1.40)	1.12	(0.89, 1.49)

p < 0.05, p < 0.01, p < 0.01, p < 0.001.

Table 6

Age and sex adjusted odds ratios for cause-specific mortality, by race and stroke belt birth/residence (ages 55 and over), controlling for self-rated health.

Outcomes	Birth and Residence Modeled Separately				Birth and Residence Modeled Together			
	Stroke Belt Birth		Stroke Belt Residence		Stroke Belt Birth		Stroke Belt Residence	
	Odds Ratio	95% CI	Odds Ratio	95% CI	Odds Ratio	95% CI	Odds Ratio	95% CI
White population								
All Cause Dementia	1.08**	(1.02, 1.15)	1.15***	(1.09, 1.22)	0.97	(0.90, 1.05)	1.17***	(1.09, 1.26)
Alzheimer's Disease	1.20**	(1.02, 1.40)	1.14	(0.99, 1.32)	1.16	(0.95, 1.42)	1.05	(0.87, 1.26)
Stroke	1.11**	(1.01, 1.22)	1.03	(0.94, 1.12)	1.15*	(1.01, 1.30)	0.95	(0.85, 1.07)
Self-Reported Stroke	1.04	(0.97, 1.11)	1.05	(0.99, 1.12)	1.01	(0.92, 1.10)	1.05	(0.97, 1.14)
Non-white population								
All Cause Dementia	1.14	(0.92, 1.41)	1.21	(0.96, 1.52)	1.05	(0.81, 1.35)	1.17	(0.89, 1.54)
Alzheimer's Disease	0.91	(0.46, 1.79)	1.02	(0.50, 2.08)	0.85	(0.38, 1.92)	1.12	(0.48, 2.62)
Stroke	1.01	(0.75, 1.37)	0.80	(0.56, 1.16)	1.17	(0.82, 1.68)	0.73	(0.48, 1.12)
Self-Reported Stroke	1.06	(0.87, 1.30)	1.14	(0.92, 1.41)	0.99	(0.78, 1.26)	1.14	(0.89, 1.48)

p < 0.05, p < 0.01, p < 0.01, p < 0.001.

Table 7

Age, and adjusted odds ratios for cause-specific mortality, by race and stroke belt birth/residence (ages 55 and over), controlling for self-reported stroke.

Outcomes	Birth and Residence Modeled Separately				Birth and Residence Modeled Together			
	Stroke Belt Birth		Stroke Belt Residence		Stroke Belt Birth		Stroke Belt Residence	
	Odds Ratio	95% CI	Odds Ratio	95% CI	Odds Ratio	95% CI	Odds Ratio	95% CI
White population								
All Cause Dementia	1.13***	(1.06, 1.20)	1.17***	(1.10, 1.23)	1.03	(0.95, 1.11)	1.15***	(1.07, 1.23)
Alzheimer's Disease	1.21*	(1.04, 1.41)	1.17*	(1.01, 1.34)	1.15	(0.94, 1.40)	1.08	(0.90, 1.30)
Stroke	1.16**	(1.06, 1.27)	1.05	(0.96, 1.15)	1.21**	(1.07, 1.36)	0.94	(0.84, 1.06)
Non-white population								
All Cause Dementia	1.24*	(1.01, 1.52)	1.30*	(1.04, 1.62)	1.12	(0.87, 1.44)	1.21	(0.92, 1.58)
Alzheimer's Disease	0.90	(0.46, 1.76)	1.01	(0.50, 2.06)	0.85	(0.38, 1.90)	1.12	(0.48, 2.60)
Stroke	1.06	(0.78, 1.43)	0.83	(0.58, 1.20)	1.22	(0.85, 1.75)	0.74	(0.48, 1.13)

p < 0.05, p < 0.01, p < 0.01, p < 0.001.

of this research has put greater emphases on individual level factors and contemporary geographic contests, rather than early life environments (Datta et al., 2012; Hamad et al., 2016). The aim of this paper was to test the importance of early life environments, measured by birthplace in the stroke belt, in predicting the likelihood of cause-specific mortality. The analyses in this paper show that there is a higher likelihood of mortality from stroke, dementia, and Alzheimer's Disease for those born in the stroke belt. We fail to find statistical differences in these results by white/non-white status but acknowledge that our sample sizes are modest for the (already crudely combined) "nonwhite" group.

These findings support and are consistent with previous studies that have been done on the stroke belt and causes of death (Glymour et al., 2009, 2011; Howard & Howard, 2020; Howard et al., 2013; Wadley et al., 2011). However, these studies often were conducted with either vital statistics that lack individual level control variables or smaller sample sizes that focused on a single state. Therefore, we were able to add additional information and controls, such as education and self-rated health into our analysis. Specifically, the results of Table 5 are in line with previous literature (Glisanz et al., 2017), and show that education does not seem to mediate the links between the stroke belt birth and mortality using national-level data. These results are similar to other works that show that forms of socioeconomic status account for only minor (about five percent) portions of excess mortality in the stroke belt region, despite this region of the United States having a lower socioeconomic status on average (Howard et al., 1997; Howard & Howard, 2020). Other mechanisms linking geography with health that have been discussed in other work include depression, discrimination, and stress (Howard & Howard, 2020); our data does not adequately capture these measures and additional future work will be necessary to test for mediation. Ultimately, the results in this paper also appear to contrast with the importance of cognitive reserve and its role in dementia-related outcomes (Meng & D'Arcy, 2012).

There are some limitations of this study to address. First, while we have large national individual level data, we do have some limited coverage of place of residence during old age. In terms of the states utilized for place of residence, it includes eight states of residence, and therefore is not a nationally representative sample. Additionally, we have used a larger range of ages to compensate for our low prevalence of these specific causes of death categories in this population, though we still have some limited power to detect modest effect sizes for impacts for non-white respondents. Future studies should look into replicating this analysis that include larger samples of non-white populations to identify the depth of racial disparities of mortality in the stroke belt. The estimated effects of both birth in the stroke belt and residence in the stroke belt present issues of interpretation. The potential of selective migration could bias results for state of residence. For instance, it is possible that healthier individuals born in the stroke belt leave, or unhealthy people migrate to the stroke belt in later life, thus producing results that have some bias. Additionally, our measure of birth in the stroke belt fails to capture the length of residence in the stroke belt and thus is a mixture of the effects of longer and shorter residence lengths among sample members.

Conclusion

This research is unique due to the advantages of our data that allow us to explore non-fatal health measurements as pathways preceding mortality measurement. The data enables us to examine the extent that factors such as education work as a mechanism in determining mortality. Our results ultimately suggest that there is limited evidence of this pathway. Moreover, other factors, such as self-rated health status, suggest both broad health effects and residual impacts concerning mortality in later life. Future studies would benefit by employing larger sample sizes, particularly for non-white populations, and including additional states of residence as well as continue to examine different types of mortality. Additionally, research should examine inter-state heterogeneity to further document life course effects of exposures. Nevertheless, this study and the data used in this study are an important contribution to the broader literature about geographic disparities in mortality and health in later life.

Author contribution statement

Conceptualization: JF, JK. Methodology: JF, JK. Writing—Original Draft: MT.

Appendix

Table 1

Age and Sex Adjusted Odds Ratios for Cause-Specific Mortality, by Race and Stroke Belt Birth/Residence (Ages 55 and Over), Health Control Removed.

	Stroke Belt Birth				Stroke Belt Bir			
	Odds Ratio	95% CI	Odds Ratio	95% CI	Odds Ratio	95% CI	Odds Ratio	95% CI
	Whites		Whites X Stroke Belt Birth		Whites		Whites X Stroke Belt Birth	
Pooled sample								
All Cause Dementia	1.13***	(1.07, 1.20)	1.12	(0.90, 1.38)	1.03	(0.95, 1.11)	1.14	(0.92, 1.42)
Alzheimer's Disease	1.21*	(1.04, 1.41)	0.75	(0.38, 1.50)	1.14	(0.94, 1.39)	0.76	(0.38, 1.52)
Stroke	1.17**	(1.07, 1.29)	0.94	(0.68, 1.28)	1.23***	(1.10, 1.39)	0.92	(0.67, 1.27)
Self-Reported Stroke	1.19***	(1.11, 1.27)	1.06	(0.87, 1.30)	1.17***	(1.07, 1.27)	1.07	(0.87, 1.31)

p < 0.05, p < 0.01, p < 0.01

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Ethical statement

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