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Article

State inequality, socioeconomic position and subjective cognitive decline in the United States

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ABSTRACT

Background: Social gradients in health have been observed for many health conditions and are suggested to operate through the effects of status anxiety. However, the gradient between education and Alzheimer's disease is presumed to operate through cognitive stimulation. We examined the possible role of status anxiety through testing for state-level income inequality and social gradients in markers of socioeconomic position (SEP) for Alzheimer's disease risk.

Methods: Using data from the cross-sectional 2015 and 2016 Behavioral Risk Factor Surveillance System (BRFSS) and the U.S. Census Bureau's American Community Survey, we tested for the association between U.S. state-level income inequality and individual SEP on subjective cognitive decline (SCD) – a marker of dementia risk – using a generalized estimating equation and clustering by state.

Results: State income inequality was not significantly associated with SCD in our multivariable model (OR 1.2; 95% CI: 0.9, 1.6; p = 0.49). We observed a clear linear relationship between household income and SCD where those with an annual household income of 50k to 75k had 1.4 (95% CI: 1.3, 1.6) times the odds and those with household incomes of less than $10,000 had 4.7 (95% CI: 3.8, 5.7) times the odds of SCD compared to those with household income of more than $75,000. We also found that college graduates (ref.) and those who completed high school (OR: 1.1; 95% CI 1.04, 1.2) fared better than those with some college (OR: 1.3, 95% CI 1.2, 1.4) or less than a high school degree (OR: 1.5; 95% CI: 1.4, 1.7).

Conclusions: Income inequality does not play a dominant role in SCD, though a social gradient in individual income for SCD suggests the relationship may operate in part via status anxiety.

1. Background

Over the past several decades, researchers have observed a "social gradient in health" where each step down on the social ladder is associated with worse health outcomes – even when comparing different status levels of middle-class office workers (Marmot et al., 1991). This growing body of literature has demonstrated that the influence of socioeconomic position (SEP) on health outcomes is not merely due to the material deprivation among those living in poverty, but may be attributed, in part, to status rankings between individuals (Marmot, 2004; Wilkinson, 1999). Known as the "relative income hypothesis," this pattern in health outcomes is theorized to operate through a psychosocial/stress response to social comparisons (Mullahy, Robert, Wolfe, Robert, & Wolfe, 2011). Additional studies suggest that individuals in societies with higher levels of income inequality may experience an increased sense of social comparison, or "status anxiety," such that income inequality may be an important independent risk factor for health conditions with social gradients beyond what is accounted for by the individual's SEP (Pickett & Wilkinson, 2015).

The association between income inequality and health has been replicated in cross-national comparisons, and in studies that examine differences between U.S. states for a variety of health conditions (Kim, Kawachi, Hoorn, & Ezzati, 2008; Pickett & Wilkinson, 2015; Van Deurzen, Van Ingen, & Van Oorschot, 2015). The status anxiety hypothesis suggests that rising inequality has a direct effect on health via its activation of the body's stress-response system, which produces worse health outcomes (Beckie, 2012; Kondo, Kawachi, Subramanian, Takeda, & Yamagata, 2008; Mishra & Carleton, 2015; Singh-Manoux, Adler, & Marmot, 2003). However, debate continues over if and how income inequality may affect individual health above the effects of

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individual SEP. Several proposed mechanisms may help to explain observed relationships, including the differences in social spending on education and health care, and social support for public health that may prevail in more economically equal societies (Kawachi & Kennedy, 1999). The inequality-health relationship has been observed for a variety of health conditions that could be influenced by stress-response, including life expectancy, cardiovascular health and mental health (Kim et al., 2008; Pickett & Wilkinson, 2015; Van Deurzen et al., 2015). To our knowledge, no one has examined the effect of income inequality on age-related cognitive decline or dementia, though there are pertinent theoretical and practical reasons to do so.

More than 5 million people in the U.S. have been diagnosed with Alzheimer's disease, the most common type of dementia, and it is estimated this will increase to 11.6 million by 2025 (Hebert, Weuve, Scherr, & Evans, 2013). As the number of people living with dementia increases, the demand for dementia care services to help with the declines in cognition and independent functioning that are part of the disease is expected to continue to outpace the capacity of medical and long-term care systems, with substantial financial and health impacts to individuals, families and society (Alzheimer's Association, 2018; De Vugt & Verhey, 2013; Plassman et al., 2007; Richardson, Lee, Berg-Weger, & Grossberg, 2013; World Health Organization, 2012).

Dementia is typically diagnosed through a clinical assessment of changes in cognition that begin to substantially interfere with one's ability to fulfill their daily activities. However, dementia is at the severe end of a continuum of age-related cognitive decline that often begins with self-identified changes in cognitive functioning, or subjective cognitive decline (SCD). SCD may not be detectable by a clinical screening test, though it is increasingly recognized as a reliable predictor of objectively assessed cognitive decline, including among those with higher levels of education who tend to perform better on clinical assessments (Reisberg, Shulman, Torossian, Leng, & Zhu, 2010; van Oijen, de Jong, Hofman, Koudstaal, & Breteler, 2007). Though not all cases of SCD or clinically detectable cognitive decline will progress to dementia, SCD can have meaningful impacts on functional abilities and serves as an important early identifier of those most at risk for dementia (Kaduszkiewicz et al., 2014; Marcos et al., 2016; Mitchell & Shiri-Feshki, 2009; Taylor, Bouldin, & Mcguire, 2018).

A social gradient has been observed for age-related cognitive decline by occupational status and income, though some studies note that these associations are substantially attenuated or nullified after accounting for the effect of education (Anttila et al., 2002; Karp et al., 2004; Staff, Chapko, Hogan, & Whalley, 2016; Zeki Al Hazzouri, Haan, Galea, & Aiello, 2011). Educational attainment is one of the best documented modifiable risks for age-related declines in cognition, and has been shown to have a dose-response relationship with clinically-assessed cognitive outcomes (Beydoun et al., 2014; Xu et al., 2016). The body of evidence for the relationship between cognitive decline and education has largely pointed to a direct effect of cognitive stimulation resulting from education as the underlying mechanism for better late-life cognitive outcomes (Carvalho et al., 2015; Jefferson et al., 2011; Meng & D'Arcy, 2012). Cognitive stimulation is hypothesized to have a protective effect for cognition through promoting "cognitive reserve," or the increased efficiency and capacity of neural networks in the presence of dementia pathology (Stern, 2009). Theoretically, cognitive stimulation is thought to allow for greater cognitive flexibility that allows an individual to continue to function well, even in the presence of dementia-related brain pathologies (Martínez et al., 2018; Meng & D'Arcy, 2012).

However, it is plausible that the effects of education and other markers of SEP on cognitive decline could operate in part through status anxiety. Theoretically, status anxiety contributes to the over-activation of the body's stress response and can result in physiological damage operationalized through a composite of biomarkers that measure allostatic load (McEwen, 2012; Wilkinson & Pickett, 2017). Importantly, allostatic load has direct neurocognitive influences on memory and cognitive functioning that may contribute to the risk of Alzheimer's disease (Booth et al., 2015; Juster, McEwen, & Lupien, 2010; Lesuis et al., 2018). Examining the relationship between cognitive decline, inequality and individual markers of SEP may therefore help to shed light on the underlying mechanism between the SEP-cognitive decline relationship, and provide additional evidence for or against the role of inequality in health, and the debated status anxiety hypothesis.

The aim of this study was to test for an association between subjective cognitive decline (SCD) as an early predictor of dementia risk, measures of individual SEP, and state-level income inequality in the U.S. We hypothesize finding evidence for status anxiety hypothesis via presence of a social gradient in markers of individual SEP, and that higher state-level income inequality will be associated with higher odds of SCD after controlling for individual-level SEP. Additionally, this study conducted a secondary examination of status anxiety by modeling an interaction between individual income and income inequality to see if those with lower household income would be negatively affected by income inequality to a greater degree than those with higher household income. Theoretically, a social gradient in the markers of SEP – especially income – and a relationship between income inequality and cognitive decline would support the hypothesis that income inequality impacts health through the psychosocial pathway of status anxiety. If these relationships are not observed, alternative mechanisms should be considered to explain the observed social gradients in health, which for cognitive decline and Alzheimer's disease risk may be cognitive stimulation.

2. Methods

2.1. Data sources

We used the Cognitive Decline module from the 2015 and 2016 Behavioral Risk Factor Surveillance System (BRFSS). The BRFSS is a cross-sectional telephone survey conducted annually by the United States Centers for Disease Control and Prevention that collects self-reported health information from community-dwelling adults (Centers for Disease Control and Prevention, 2016b). The cognitive decline module was asked of all participants age 45 or older who resided in a state that elected to participate in the module. All states except Pennsylvania and Washington D.C. participated in the cognitive decline module in 2015 or 2016. New Jersey, New York, Oregon, Tennessee and Utah participated in the cognitive decline module in both years; for these states we included only the 2016 participants, providing a total of 50 clusters (49 states and Washington D.C.). Puerto Rico participated in 2015, but was excluded from analysis because it is an outlier on our key variables of interest; Puerto Rico has substantially lower household income (median US$19,606) and slightly higher income inequality (Gini coefficient = 0.542; U.S. state min/max = 0.408, 0.535) than any U.S. state (United States Census Bureau, 2016).

2.2. Subjective cognitive decline

The primary outcome of this study was the dichotomized response to an item measuring subjective cognitive decline (SCD), obtained from the BRFSS cognitive decline module. Participants were classified as having SCD if they responded yes to the question: "During the past 12 months, have you experienced confusion or memory loss that is happening more often or is getting worse?".

2.3. Individual socioeconomic position

We used variables from the BRFSS for household income, education and home ownership as markers of SEP. Income was provided in 8 categories ranging from < $10,000 to ≥ $75,000; the highest income category was modeled as the reference. Education was categorized as

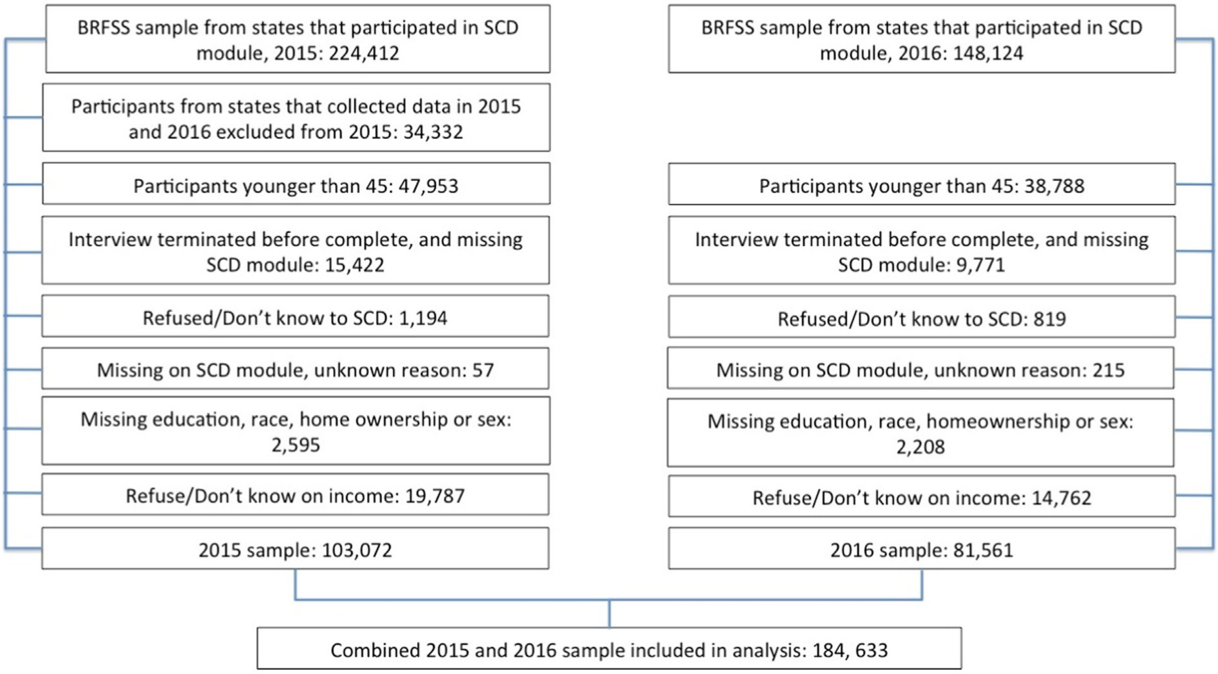

Fig. 1. Primary analysis inclusion and exclusion criteria for study participants who resided in states that participated in the Behavioral Risk Factor Surveillance System cognitive decline module in 2015 or 2016. Multiple imputation was conducted in sensitivity analysis to account for missing data.

less than high school, high school graduate, some college or technical school, and college or technical school graduate, with the highest education category as the reference. Homeownership was modeled as a dichotomous variable with owners as the reference.

2.4. State-level income inequality

As a measure of states' income inequality, we used the Gini coefficients based on the 2015 and 2015 American Community Survey (ACS), an annual survey of about 3.5 million households (United States Census Bureau, 2015). This indicator, published by the U.S. census bureau, is one of the most commonly used measures of income inequality. Its value ranges from 0 (complete equality) to 1 (one household captures all income); (De Maio, 2007).

2.5. Individual covariates

Adjusted models controlled for gender, age and race/ethnicity, provided by the BRFSS. Race/ethnicity was categorized as non-Hispanic white (reference), non-Hispanic black, Hispanic/Latino, Asian, and an "other" category comprised of respondents who reported their race as American Indian/Alaska Native, Pacific Islander/Hawaiian, mixed race or other. Age was modeled categorically at 45–49 (reference); 50–59; 60–69; 70–79; and top-coded at ≥80 years, as available in the BRFSS.

2.6. Statistical analysis

We matched the 2015 and 2016 BRFSS datasets with 2015 and 2016 income inequality data from the ACS, respectively (United States Census Bureau, 2015, 2016). In the primary analysis, we included participants of the cognitive decline module who had valid responses for age, sex, race/ethnicity, education, home-ownership and income. We calculated weighted proportions of demographic and health characteristics of participants based on SCD status and used chi-square tests to compare the demographic characteristics of those with SCD to those without SCD.

To test for the effects of individual SEP and state-level income inequality on SCD, we used a Generalized Estimating Equation (GEE) with a logit link and independent working covariance, clustered by the participant's state of residence to fit unadjusted and adjusted models. Using a GEE model allowed us to specify the nested nature of the data within each U.S. state and account for heterogeneity of income inequality between states. The GEE provides an average estimate of effect of SCD for the population. This interpretation is in contrast to multilevel models, which estimate the effect for a specific participant, conditional on the covariates in the model, including the state (Hubbard et al., 2010). Some methodologists argue that the population averaged model (GEE) is more appropriate when the research question focuses on neighborhood or state effects (Hubbard et al., 2010).

We tested for effect modification of household income grouped at 3 levels with state-level income inequality to examine if the impact of income inequality varies depending on one's income, by including an interaction term. We also performed two sensitivity analyses. First, we recalculated our analysis use lagged Gini coefficients from 2005 and 2010, computed by the Census Bureau based on 5 years of ACS data (United States Census Bureau, 2015). While these models are more likely to result in state level misclassification (individuals are more likely to move between states within 5 years or 10 years than 1 year), it also has the strength of capturing the contextual effect of income inequality, which may take years to influence health. Second, we conducted multiple imputation using chained equations to account for the high degree of missing data on income. Of the 223,985 participants of the SCD module in 2015 and 2016, 2.1% were missing information on education, race, homeownership or sex, and 15.4% were missing household income data. We performed 200 imputations with all variables from the primary model. We also included variables from the BRFSS dataset that are conceptually or empirically linked with missing income data and that were correlated with income at ≥ 0.3: internet use in the past 30 days, 30-day self-reported health, marital status and employment status (Azur, Stuart, Frangakis, & Leaf, 2011).

Appropriate population weights provided by the BRFSS were applied in all models following guidance available on the BRFSS website (Centers for Disease Control and Prevention, 2016a). Application of these weights adjusts each state's participant sample so it is representative of its population. All analyses were conducted in Stata 14.2 (College Station, TX).

Table 1
Demographic characteristics of adults aged 45 and older as a function of Subjective Cognitive Decline[a] status, Behavioral Risk Factor Surveillance System 2015 and 2016.

	SCD N = 19,662 Weighted %	No SCD N = 164,971 Weighted %	p-value[b]
Household Income ($US)			
≥ $75,000	6.0	94.0	< 0.001
≥ $50,000 & < $75,000	8.6	91.4	
≥ $35,000 & < $50,000	10.4	89.6	
≥ $25,000 & < $35,000	13.7	86.3	
≥ $20,000 & < $25,000	15.3	84.7	
≥ $15,000 & < $20,000	17.4	82.6	
≥ $10,000 & < $15,000	21.2	78.8	
< $10,000	26.3	73.7	
Years of Education			
College Graduate	7.0	93.0	< 0.001
Some College	11.5	88.5	
High School Graduate	11.8	88.2	
Less than High School	18.7	81.3	
Homeowners	10.0	90.0	< 0.001
Non-homeowners	17.4	82.6	
Female	11.1	88.9	0.55
Male	11.4	88.6	
Age			
45–50	9.7	90.3	< 0.001
50–59	11.1	88.9	
60–69	10.4	89.6	
70–79	11.9	88.1	
80 +	16.6	83.4	
Race/Ethnicity			
Non-Hispanic White	10.9	89.1	< 0.001
Non-Hispanic Black	13.0	87.0	
Hispanic	11.6	88.4	
Asian	6.0	94.0	
Other	17.6	82.4	

[a] Self-reported experience with confusion or memory loss that is happening more often or getting worse in the last 12 months.
[b] X^2 test, adjusted for sampling weights

3. Results

Of the 223,985 who completed the cognitive decline module, 184,633 had complete data and were included in the primary analyses (Fig. 1). On average, participants who were older, had less than a college or technical school education, were not non-Hispanic white or Asian and were not homeowners were more likely to report SCD (Table 1). Additionally, 52.1% of those without SCD reported a household income of more than $50,000 a year, compared to 30.2% of those with SCD.

In the primary analysis, we did not find a statistically significant association between state-level income inequality and SCD, though the odds ratio was in the direction predicted. In unadjusted analysis, the odds of SCD increased 1.2 (95% CI: 0.9, 1.5; p = 0.18) times for each 0.1 unit increase in income inequality, as measured by the Gini coefficient (Table 2). Similarly, in adjusted analyses, the odds ratio for income inequality was 1.2 (95% CI: 0.9, 1.6; p = 0.28). The predicted probability of SCD for those in the most equal state (Gini = 0.408) was 0.09, compared to the least equal state (Gini = 0.535) at 0.11. Overall, the change in predicted probabilities for or every .05 unit increase in the Gini coefficient resulted in less than a 1%-point increase in the predicted probability of SCD, when all covariates were at their mean levels. However, all three measures of SEP (household income, education and home ownership) were protective for SCD. Our results for household income reflected a social gradient in health, with an increasing stepwise protective effect for each higher income category. Compared to those with a household income of more than $75,000 a year, participants with household incomes between $50,000 and $75,000 were 1.4 (95% CI: 1.3, 1.6) times more likely to report SCD, while those with household incomes of less than $10,000 per year were 4.7 (95% CI: 3.8, 5.7) times more likely to report SCD. Higher education also was a protective factor for SCD, though the pattern was not consistent. Compared with college or technical school graduates, those with less than high school had the highest odds of SCD at 1.5 (95% CI: 1.4, 1.7) times, high school graduates had 1.1 (95% CI: 1.0, 1.2) times the odds, and those with some college or technical school had 1.3 (95% CI: 1.2, 1.4) times the odds. Compared with homeowners, those who rented or had another living arrangement were 1.2 (95% CI: 1.1, 1.3) times more likely to report SCD.

We found no evidence of effect modification between income inequality and household income, indicating that the effect of income inequality on SCD does not vary by household income level (Table 3). Additionally, our sensitivity models that examined separately the effect

Table 2
Association of state-level income inequality (Gini coefficient), individual socioeconomic position and subjective cognitive decline* from the Behavioral Risk Factor Surveillance System 2015 and 2016.

	2015–2016 Gini, matched to BRFSS year		
	OR	95% CI	p-value
State income inequality (unadjusted)[a]	1.19	0.92, 1.56	0.19
State income inequality(adjusted)[a]	1.19	0.87, 1.62	0.281
Household Income			< 0.001
≥ $75,000	Ref		
≥ $50,000 & < $75,000	1.40	1.26, 1.56	
≥ $35,000 & < $50,000	1.67	1.53, 1.83	
≥ $25,000 & < $35,000	2.22	1.91, 2.58	
≥ $20,000 & < $25,000	2.50	2.11, 2.98	
≥ $15,000 & < $20,000	2.81	2.35, 3.37	
≥ $10,000 & < $15,000	3.52	3.97, 4.17	
< $10,000	4.66	3.79, 5.74	
Education			< 0.001
College or technical school graduate	Ref		
Some college	1.30	1.22, 1.39	
High school graduate	1.12	1.04, 1.21	
Less than High School	1.51	1.36, 1.68	
Non-homeowners	1.19	1.07, 1.33	0.002

Adjusted ORs control for age, race and sex.
[a] OR is based on a 0.1 unit change in Gini coefficient.
* Self-reported experience with confusion or memory loss that is happening more often or getting worse in the last 12 months.

Table 3
Effect of state-level income inequality (Gini coefficient) on subjective cognitive decline* at each level household income (inequality x income) from the Behavioral Risk Factor Surveillance System 2015 and 2016.

	OR	95% CI	p-value
State income inequality[a]			0.43[c]
≥ $75,000	1.18	0.74, 1.90	
≥ $35,000 & < $75,000	1.40	0.80, 2.44	
< $35,000	1.12	0.86, 1.45	
Education			< 0.001
College or Technical School Graduate	Ref.		
Some College	1.30	1.22, 1.39	
High School Graduate	1.15	1.05, 1.25	
Less than High School	1.67	1.49, 1.87	
Non-homeowners	1.30	1.17, 1.45	< 0.001

Model controls for age, race and sex.
[a] OR is based on a 0.1 unit change in Gini coefficient.
* Self-reported experience with confusion or memory loss that is happening more often or getting worse in the last 12 months.
[c] P-value for the test of the state income inequality by household income.

of the ACS 5- and 10-year lagged Gini coefficients produced comparable results to our original findings (see Table 4 in supplementary materials). The results of our multiple imputation sensitivity analysis were also comparable to our primary analysis (see Table 5 in supplementary materials), indicating the robustness of our findings in spite of substantive missing data on income.

4. Discussion

4.1. Summary of findings

The primary objective for this study was to examine the relationship between state-level income inequality, markers of individual SEP and SCD. We hypothesized that income inequality would be positively associated with SCD after accounting for individual-level SEP. We did not observe a statistically significant relationship between state-level income inequality and SCD in the models tested. While the effect was in the direction predicted, it was substantively small and statistically insignificant. However, we did observe a clear and statistically significant social gradient in health where odds of SCD decreased for each step higher of household income. We also observed significant positive associations for SCD with homeownership and higher education.

4.2. Interpretation

Our findings suggest that income inequality in itself may not have a substantial influence on SCD and dementia risk. This finding reinforces some of the critiques of the income inequality hypothesis. Specifically, critics have argued that any observed relationships between income inequality and health are not likely resulting from a direct effect, but rather income inequality is more likely a mediator in the relationship between other structural processes and health, such as the social distribution of public goods and services (Mellor & Milyo, 2001; Mullahy et al., 2011). Accordingly, many critics also argue that non-psychosocial factors that have a material impact on individual health, such as neighborhood poverty level and race-based residential segregation, may better explain the observed effects (Goldthorpe, John, 2010; Lynch, 2000; Massey & Denton, 1993; Mullahy et al., 2011). Correspondingly, many studies on dementia risk point to the unequal distribution of education across race and class lines as a key explanatory mechanism of disparities in dementia risk, operating via cognitive stimulation (Beydoun et al., 2014; Chin, Negash, Xie, Arnold, & Hamilton, 2012; Crowe et al., 2013; Jefferson et al., 2011; Kaup et al., 2014).

However, while income inequality may not be an important risk factor for SCD, our findings do not preclude the possible role of status anxiety and the psychosocial pathway for individual dementia risk. We observed relatively large and significant differences in odds of SCD, even among those in the top income categories, as would be expected if status anxiety were an operating mechanism. Additionally, our findings for the association between education and SCD suggest that social status, rather than cognitive stimulation, may be a contributing mechanism for the dementia-education association. Specifically, we observed that graduates of college or technical school and high school fare better than non-completers of either degree. If cognitive stimulation were the dominant mechanism in the relationship between education and dementia risk, as posited by the cognitive reserve hypothesis, more years of education among those who started but did not complete college or technical school should theoretically have a stronger protective effect than what is observed among high school graduates. The effect of education operating as a potential status marker rather than via cognitive stimulation is also supported by findings from some studies from low- and middle-income countries where average education and literacy levels are low, and there is not a clear link between education and dementia (Chandra et al., 2001; Hall, Gao, Unverzagt, & Hendrie, 2000).

Overall, our findings indicate that dementia risk may not be influenced by income inequality, or exclusively determined by early life factors such as education. Rather, it is possible that the effects of both education and income on dementia risk operate, in part, through social comparisons that may be fueled by resource distribution and other forms of structural inequalities that extend beyond the distribution of income. However, it is also possible that these findings reflect other mechanisms shaped by income and education, such as health behaviors.

4.3. Methodological considerations

The literature linking. income inequality to health is mixed, and frequently dependent upon study design (Kragten & Rözer, 2017), the geographic unit of measurement (Pickett & Wilkinson, 2015), and accurately accounting for the state-level factors that may confound the relationship (Kondo et al., 2009). Our study design and analyses took into account the effect of state context of income inequality, and U.S. states have been observed as sufficiently large and heterogeneous to be sensitive to an effect of income inequality as measured by the Gini coefficient, while counties or cities are often too small to be sensitive to an effect (Bernabé & Marcenes, 2011; Pabayo, Kawachi, & Gilman, 2014; Pickett & Wilkinson, 2015). However, there may be other unmeasured state-level factors that confound the relationship between income inequality and SCD that we could not include in our models, such as state variation in the provision of social services (Bradley et al., 2016). Furthermore, recent research suggests that in some cases the Gini coefficient may not be as sensitive to the effects of income inequality on health as are other markers of inequality, such as the income share of the top 1% or 5% (Hill & Jorgenson, 2018). The key difference between income shares and the Gini coefficient is in the ability to account for income inequality at the very top and bottom of the income distribution. Because the Gini coefficient is less sensitive to inequalities at the tail ends of the income distribution, geographies with substantially different income distributions theoretically could have similar Gini coefficients (Palma, 2011).

4.4. Limitations

Our study had several limitations. First, we were unable to determine the temporal ordering of the relationship between SCD and markers of SEP due to the cross-sectional design. While educational attainment is often established early in the life course, both income and cognition tend to decline as individuals age. In this study it was impossible to know if SCD predated or contributed to lower income levels, such as through early retirement resulting from cognitive decline. A second limitation was in the restricted availability of household income data. Income in the BRFSS is top-coded at $75,000, limiting our ability to examine if the social gradient we observed between SCD and income continues in a linear fashion for those with income levels above $75,000, or plateaus after a particular threshold of household income. A third key limitation in this analysis was in our inability to account for an adequate lag time or a cumulative exposure of state-level income inequality. While our sensitivity analysis demonstrated similar effects of the Gini coefficient when averaged at 5 and 10 years prior to our outcome, our concern over state misclassification (the BRFSS does not provide information on length of state residence or prior state of residence) discouraged us from examining longer lagged effects that may be influential in dementia risk.

4.5. Future directions

The income gradient and protective effect of completing educational degrees evidenced in this study adds to the body of knowledge for dementia risk, suggesting that income and the effects of status anxiety may be important to consider for dementia risk in addition to the effects of education and cognitive stimulation. Future studies should further examine the role of income inequality, individual SEP and status anxiety on dementia risk in datasets with more explicit measures of perceived social status and employing alternative measures of income inequality. Additionally, cohort studies with available biomarkers for allostatic load or brain imaging would allow for more direct examination and comparison of the effect of individual SEP and income inequality on status anxiety and cognitive reserve as hypothesized mechanisms of dementia risk. A third avenue for exploration is in how the effect of income-based policies and programs throughout the life course shape exposure to income inequality and age-related cognition decline. Already, there is some evidence for a protective effect of late-in-life income beyond the effects of earlier life income for dementia risk (Anttila et al., 2002; Ayyagari & Frisvold, 2016). Future studies could further clarify the role and timing of income-based interventions for reducing the risk of dementia.

In the absence of effective prevention or treatment for dementia, early interventions that target the modifiable risk factors for cognitive decline are the only available strategy for addressing a dementia epidemic (Fink et al., 2018; Livingston et al., 2017). As the population ages and more individuals are at risk of age-related cognitive decline, all plausible possibilities for risk reduction should be considered. A recent report from the Lancet Commission on Dementia Prevention, Intervention, and Care called for researchers and health care providers to "be ambitious" about dementia by reducing known risk factors (Livingston et al., 2017). Increasing income and lowering chronic stress may prove to be a central and important part of an ambitious approach to reduce the risk of dementia.

Author declaration

None.

Note

The findings and conclusions in this article are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Conflicts of interest

None of the authors have any conflicts of interest or funding sources to disclose for this study.

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Appendix A. Supporting information

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