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Stroke-Attributable Death Among Older Persons During the Great Recession

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Abstract

Epidemiological evidence indicates an elevated risk for stroke among stressed persons, in general, and among individuals who have lost their job, in particular. We, therefore, tested the hypothesis that stroke accounted for a larger fraction of deaths during the Great Recession than expected from other deaths and from trends, cycles, and other forms of autocorrelation. Based on vital statistics death data from California spanning 132 months from January 2000 through December 2010, we found support for the hypothesis. These findings appear attributable to non-Hispanic white men, who experienced a 5% increase in their monthly odds of stroke-attributable death. Total mortality in this group, however, did not increase. Findings suggest that 879 deaths among older white men shifted from other causes to stroke during the 36 months following the start of the Great Recession. We infer the Great Recession may have affected social, biologic, and behavioral risk factors that altered the life histories of older white men in ways that shifted mortality risk toward stroke.

Keywords

Stroke; Mortality; Great Recession

1. Introduction

The Great Recession, which officially began in December 2007 (National Bureau of Economic Research, 2014), affected virtually all sectors of the U.S. economy and induced the deepest downturn in employment since the end of World War II (Goodman and Mance, 2011). Despite the intuition that such a circumstance would adversely affect public health,

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studies of the relationship between the Great Recession and mortality in the U.S. and elsewhere have produced inconsistent findings (Burgard et al., 2013; Stuckler et al., 2014). Indeed, this inconsistency characterizes the larger research studying the association between mortality and economic contraction (Catalano et al., 2011). Some research has hypothesized and found that mortality from several common causes (e.g., work accidents) falls when labor markets weaken (e.g., (Catalano, 1979; Gerdtham and Ruhm, 2006), while other research reports deaths from other causes rising during economic contraction (e.g., (Stuckler et al., 2009).

Reviews (Catalano et al., 2011; Stuckler et al., 2014) of the literature connecting recessions to mortality have noted that the disparate findings may arise not only from differences in method (Bruckner et al., 2013), but also from heterogeneity in the spatial and temporal mix of mechanisms that set older persons, who disproportionately contribute to mortality, on trajectories to death. While some of these mechanisms may accelerate in response to economic circumstances, others may slow. This possibility suggests a research strategy that focuses, at least at the outset, on causes of mortality for which recession would likely “harvest” deaths among older persons whose trajectories would otherwise have spread their deaths more evenly over time or across causes.

Although earlier literature suggests that the distribution of causes of death shift during recessions (Gallo et al., 2004), the hypothesis has not previously been tested. For reasons described below, we suspect that economic contraction may accelerate death by stroke and thereby “harvest” deaths from other causes or from the future. We test this suspicion using stroke deaths in California before and during the Great Recession.

Although each individual has a unique history of genetic endowment as well as of social experiences and environmental exposures, commonalities among these histories allow epidemiologists and demographers to identify groups that differ significantly in morbidity and longevity (Olshansky et al., 2005; Vaupel, 2010; Yoon et al., 2014). The distribution of older individuals across these groups, in turn, predicts the frequency and causes of death among the elderly (Galea, 2007; Halfon and Hochstein, 2002; Vasunilashorn and Crimmins, 2009; Worthman and Kuzara, 2005). The Great Recession may have changed this distribution in the United States and elsewhere by affecting, among other factors, income, time use, access to medical care, exposure to work-related hazards, as well as by inducing stress and anxiety.

The causes of death suspected to increase during bad economic times include those responsive to stressful experiences. The biological precursors of stroke, for example, likely develop over the life course but the timing of an ischemic event appears affected by “triggers” including stressful experiences (Guiraud et al., 2013). This circumstance has, in fact, led to the suspicion that job loss may trigger stroke. Research supporting this hypothesis shows that workers over 50 years old who suffer layoff exhibit a twofold increase in stroke compared to similar workers who remain employed (Gallo et al., 2004). The association presumably arises because late-career job loss decreases income and savings and severs social interactions thereby inducing significant anxiety and psychological stress while reducing social and material support (Gallo et al., 2004). Non-transferable firm or industry-

specific skills can, moreover, lead to poor prospects of reemployment with equivalent wages and benefits (Brand et al., 2008).

The above circumstances led us to hypothesize that monthly stroke deaths among older persons exceeded those expected from deaths attributable to other causes during the Great Recession. We tested our hypothesis among 2,268,288 deaths to persons over 50 years old in California for the 132 months starting January 2000 and ending December 2010. We tested the hypothesis for the population as well as separately for men and women of white, Hispanic, and black race/ethnicity, given prior research indicating that these groups have significantly different risks for stroke mortality (Ayala et al., 2001).

2. Methods

2.1 Data

The California Department of Public Health, Center for Health Statistics & Informatics, Vital Statistics Section provided the data for this test (California Department of Public Health, 2012). Each year, the Vital Statistics section produces a file that includes data from all the death certificates registered in California as well as death certificates for California residents who die in other states. For our study period, causes of death were classified according to the International Classification of Diseases, Tenth Revision (ICD-10) (World Health Organization, 1993). We considered the following ICD-10 codes as stroke deaths: intracerebral hemorrhages (I61.0 - I61.9), cerebral infarctions (I63.0 - I63.9), and stroke not specified as hemorrhage or infarction (I64.0 - I64.9). All other causes of death, including unknown or missing causes, were coded as non-stroke mortality. Following the epidemiologic research, we constrained our analyses to person over 50 years of age.

2.2 Analyses

Our test asks whether monthly stroke deaths among older Californians during the Great Recession exceeded those expected from monthly deaths attributed to other causes. We answered that question via the following steps.

1. We regressed the 132 monthly counts of stroke deaths on the monthly counts of non-stroke deaths for the entire population and for the six sex-by-race/ethnicity groups.
2. We identified and modeled autocorrelation in the residuals of the regressions estimated in step 1. We performed this step because regressing one time series on another often leaves residuals that exhibit autocorrelation including trends, cycles, or the tendency to remain elevated or depressed, or to oscillate, after high or low values. Autocorrelated residuals violate the assumption of independence necessary to “trust” the accuracy of confidence intervals of regression parameters. Identifying and estimating autocorrelation in residuals has the added benefit of precluding a Type I error that would otherwise arise from trends that yield higher, or lower, counts of stroke deaths later in the test period and, therefore, coincidentally during the Recession.

We implemented step 2 with methods devised by Box and Jenkins (Box et al., 2008). These well-developed methods appear widely accepted in the epidemiologic literature (Catalano and Serxner, 1987; Zeger et al., 2006). Box-Jenkins methods mathematically express various filters through which time series without known patterns can pass. Each filter, or combination of filters, imposes a unique pattern. The Box-Jenkins approach uses an iterative model-building process by which the researcher infers the filter that imposed the observed pattern. The error terms of these models (i.e., the differences between the values predicted by the inferred model and the observed series) express the “unexpectedness” of observed values.

3. We created a binary “Great Recession” variable scored 0 for the 95 months before the December 2007 NBER-designated start of the Great Recession and 1 for the following 37 months.
4. We estimated test equations formed by adding the Great Recession binary variable to each of the seven models identified in step 2. These test equations take the form of “transfer functions” or regression-like equations that express autocorrelation as a function of earlier values of the dependent variable (Box et al., 2008). The general form of these transfer functions is as follows.

$$\nabla_d S_t = c + \omega_1 \nabla_d O_t + \omega_2 R_t + \frac{(1 - \theta B)(1 - \theta_n B^n)}{(1 - \phi B)(1 - \phi_n B^n)} a_t$$

∇_d is the “difference operator” that indicates a series exhibits secular trends or cycles and requires differencing (i.e., value at time $t - d$ subtracted from that at time t) to render the series stationary in its mean. S_t is the number of stroke-related deaths in California at month t . c is a constant. ω_1 and ω_2 are estimated coefficients. O_t is the number of other deaths in California at month t . R_t is the Great Recession variable scored 0 for 95 months starting January 2000 and 1 for 37 months starting December 2007. θ is a moving average parameter that measures the tendency of perturbations to be present for more than one period. ϕ is an autoregressive parameter that measures a series’ tendency to remain elevated or depressed after a perturbation. n denotes the number of moving average of autoregressive parameters in the equation. B is the “backshift operator” or value of the variable it conditions at month $t - q$ or at $t - p$. a_t is the error term at month t .

All tests of association essentially turn on whether observed data differ, as predicted by theory, from the “counterfactual” or data expected under the null hypothesis of no association. Observational tests like ours must arrive at the counterfactual from approaches other than randomized control groups. The test we describe above arrives at the counterfactual, or the number of stroke deaths assuming the Great Recession had not occurred, from two categories of phenomena. First, by including non-stroke deaths as a

covariate, the approach yields a counterfactual that includes the influence of any phenomena that produce similar effects on the odds of death by stroke and by other causes. These phenomena include, for example, changes over time in the size of population at risk, the effects of extreme weather, or availability of health care. Second, by identifying and modeling autocorrelation in residuals, the approach also builds into the counterfactual the influence of phenomena that affect stroke deaths differently from other deaths and exhibit patterns over time. The counterfactual will reflect, for example, any trends and seasonality unique to stroke deaths.

We infer support for our hypothesis that the observed monthly incidence of death by stroke exceeded the counterfactual if ω_2 in the equation shown above significantly (i.e., $p < .05$; 1-tailed test) exceeds 0. An ω_2 significantly greater than 0 implies that one of the following circumstances, all consistent with our theory, described the incidence of death among older Californians during the Great Recession: stroke deaths increased but other deaths did not; all deaths increased but stroke deaths increased faster than other deaths; or all deaths decreased but other deaths decreased more quickly than stroke deaths.

3. Results

Table 1 shows the monthly means and standard deviations of stroke and other deaths for the test groups over our 132 test months. Figures 1 through 7 show the observed incidence of death by stroke and by other causes for the analyzed groups and for the total population. These graphs provide visual evidence of autocorrelation and the heterogeneity in incidence among the groups. Whites exhibit, for example, the most obvious decline in the incidence of stroke death, while blacks show lesser trend, and Hispanics show none.

Table 2 shows the seven transfer functions estimated through the steps outlined above. Stroke deaths among all older persons in California appear more common than expected from other deaths in the population and from autocorrelation. That difference, however, appears attributable primarily to white males, who accounted for 27% of all stroke deaths among older Californians during our test period, because no other sex-by-race/ethnicity group exhibited more stroke deaths than expected from other deaths and from autocorrelation.

Our finding could, as noted in the Methods section, arise from any of three circumstances, including: 1) stroke deaths increased but all deaths did not; 2) all deaths increased but stroke deaths increased faster than other deaths; or 3) all deaths decreased but other deaths decreased more quickly than stroke deaths. To determine which circumstance best described the circumstances our results, we applied Box-Jenkins interrupted time-series methods with the binary Recession variable described above to total deaths over the 132-month test period. The estimated transfer function for this is as follows:

$$\nabla D_t = -23.8649R_t + (1 + .2805B + .2444B^2) (1 - .5389B^{12}) a_t$$

The three moving average coefficients (i.e., 0.2805, 0.2444, and -0.5389) all exceeded twice their standard errors (i.e., 0.0926, 0.0893, and 0.0798). The coefficient (i.e., -23.8649) for

the Recession variable, however, fell below its standard error (i.e., 37.1648) suggesting that total deaths during the Great Recession did not differ significantly from those expected from trends, cycles, and other forms of autocorrelation.

As a robustness check on our findings, we repeated our tests using an alternative approach. First we specified our dependent variables as the monthly natural logarithms of the odds (i.e., logits) that a death among any of the 6 race/ethnicity by sex groups had been attributed to stroke. We then used Box-Jenkins modeling routines to build the best time-series equation for the non-recession logits (i.e., 95 months ending November 2007) of each group. We next applied both the structure and coefficients of the best fitting pre-recession models to the entire 132 months of logits for each group. Finally we applied Alwan's and Roberts' (1988) outlier detection methods to determine if residuals of the 132 month models fell above their 99% confidence intervals more frequently than expected by chance during the Recession months. Consistent with the findings from our principal test, the residuals for white males appeared above expected levels during the Great Recession. The excess peaked in May 2008 and persisted, though diminished, through the end of the test period.

Figure 8 depicts the level shift detected by the Alwan and Roberts method for older white men. The points show the error terms from applying the best-fitting Box-Jenkins model for pre-recession months to all months. The lines show the pre-May and post-April 2008 means of the residuals. The mean of the pre-May values (i.e., 0) would be the mean of post-April values if the Great Recession had no effect on the odds that a death among older white men arose from stroke as opposed to other causes. The mean (i.e., 0.0492) of the post-April values was, however, significantly ($p < .001$; 2- tailed test) greater than 0.

We converted the findings of the robustness check for white men into the familiar effect-on-odds metric. Taking the antilog of the mean difference shown in Figure 8 (i.e., 0.0492) suggests that, among white men, the monthly odds of a stroke-attributed death among all deaths increased an average of 5% between May 2008 and December 2010.

To estimate the number of deaths that our findings imply shifted from other causes to stroke, we applied Box-Jenkins interrupted time-series methods with the binary Recession variable described above to stroke deaths among older white males over the 132-month test period. The estimated transfer function for this test is as follows:

$$\left(1 + .2162B^6\right) \left(1 - .4040B^{12}\right) \nabla SD_t = -.8159 + 24.4096 \nabla R_t + (1 + .8494B) a_t$$

All coefficients exceeded twice their standard errors. The coefficient (i.e., 24.4096) for the Recession variable suggested that approximately 879 deaths (i.e., $36 * 24.4096$) among older white men shifted from other causes to stroke during the 36 months following the start of the Great Recession. This estimate represented approximately 13% of the 6,696 stroke deaths during those months.

4. Discussion

We found that stroke accounted for more deaths among older Californians during the Great Recession than expected from deaths by other causes and from autocorrelation specific to stroke death. The association appeared due to deaths among white men, who experienced a 5% increase in their monthly odds of stroke-attributable death. Total mortality in this group, however, did not increase. We infer from our findings that, during the Great Recession, stroke likely “harvested” deaths among white men whose life course trajectories would otherwise have spread their deaths more evenly over time or across causes.

Many proximal mechanisms likely account for the association between the distal phenomenon of “recession” and stroke among older white men (Catalano and Dooley, 1983). Older white men may, for example, feel more connected to the equities or real estate markets than do other older men or women. They may have lost larger fractions of their income during the Recession than did other older persons. The effects—both salutary and pathological—of recessions on the biology of populations may, however, arise from phenomena other than loss of income (Gallo et al., 2006). Older white men may, therefore, have lost more than symbols of social status conferred by income (Jahoda, 1982).

Because not all segments of the economy felt the effects of the employment downturn equally (Hoynes et al., 2012), labor market attachment and earnings may also partly explain our findings. Research on job displacement and mortality, for example, indicates that mortality hazard is greater among those with higher earnings losses (Sullivan and von Wachter, 2009), and that stroke mortality hazard is significantly higher among those with higher income (Gallo et al., 2004). With white men—especially those ages 45 to 64—earning more on average compared to white women, black men and women, and Hispanic men and women (Bureau of Labor Statistics, 2011), the Great Recession may have disproportionately affected their stroke mortality risk.

We could have specified our test with multiple economic indicators such as stock prices, mortgage foreclosures, dis-employment rate, or unemployment rate and found which independent variables shared unique variance with death attributable to stroke over the range of their variation. We could have, alternatively, factor-analyzed a battery of California economic indicators and tested whether variation in a molar, subsuming “economy” construct predicted shifts in the distribution of death across causes. These exercises would have missed, however, the point of our inquiry—to assess whether the Great Recession, as a distal societal force, shifted older Californians into mechanisms likely to end with death by stroke.

We cannot, of course, rule out that the shift toward stroke as a cause of death arose from some phenomenon unrelated to, but coincident with, the Great Recession. Given our design, however, that phenomenon could not exhibit trend, cycles or any other form of correlation. It, moreover, would have to affect only older white men. We know of no phenomena that fit these criteria.

Future research should go beyond our relatively narrow focus on stroke and attempt to assess the association between the Great Recession, or other significant population stressors, and

the relative contribution of many causes of death to the total burden of mortality. Such work would require more exploratory, and perhaps less conventional, methods than those we used to test the association between the Recession and the contribution of one cause of death to total mortality.

Would our results describe places other than California during the Great Recession? We know of no reason to believe older Californians differ from other older Americans, although only further research into the effects of the Great Recession will answer the question. The circumstances referred to collectively as the Great Recession, on the other hand, have been, and will hopefully remain, rare. We do not, therefore, expect to see the associations we found in our test period during more “normal” economic times.

5. Conclusions

Our study contributes to the literature by testing whether strokes accounted for a larger fraction of deaths during the Great Recession among older persons who exhibit the highest risk of mortality. Our results suggest that, as predicted by earlier reports of elevated risk for stroke among stressed persons in general (Guiraud et al., 2013) and individuals who have lost their jobs (Gallo et al., 2004), in particular, stroke accounted for more deaths among older Californians during the Great Recession than expected. The association, however, appeared due to deaths among white men, who experienced a 5% increased above expected monthly odds of stroke-attributed deaths, as opposed to other causes of death.

While Figure 2 reflects a general downward trend in stroke deaths among older white men, statistical analysis detected that this decline flattened and actually exceeded values expected from trend and seasonality when the Great Recession set in (i.e., 2008). Total mortality in this group, however, did not vary from expected values. Taken together, our analyses suggest that approximately 879 deaths among older white men shifted from other causes to stroke during the 36 months following the start of the Great Recession. We suspect that the Great Recession shifted the distribution of older white men in California toward groups prone to imminent stroke death. We hope that future research examining the health effects of the Great Recession, or any other major ambient stressor, includes analysis of shifting risks and competing causes of death.

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Highlights

- Older Californians died more often from stroke during the Great Recession than expected from deaths attributed to other causes and from autocorrelation over the 132 test months spanning January 2000 through December 2010.
- The unexpectedly high incidence of stroke-related deaths during the Great Recession appears due to deaths among older white men, who experienced a 5% increase in their monthly odds of stroke-attributable death. Total deaths among this group did not increase above expected levels from trends, cycles, and other forms of autocorrelation.
- Findings suggest that 879 deaths among older white men shifted from other causes to stroke during the 36 months following the start of the Great Recession.
- We infer that the Great Recession may have affected social, biological, and behavioral risk factors that altered the life histories of older white men in ways that shifted mortality risk toward imminent stroke.

Figure 1.
Observed incidence of deaths by stroke and by all other causes in the total population for January 2000 through December 2010

Figure 2.
Observed incidence of deaths by stroke and by all other causes among white males for January 2000 through December 2010

Figure 3.
Observed incidence of deaths by stroke and by all other causes among black males for January 2000 through December 2010

Figure 4.
Observed incidence of deaths by stroke and by all other causes among Hispanic males for January 2000 through December 2010

Figure 5.
Observed incidence of deaths by stroke and by all other causes among white females for January 2000 through December 2010

Figure 6.
Observed incidence of deaths by stroke and by all other causes among black females for January 2000 through December 2010

Figure 7.
Observed incidence of deaths by stroke and by all other causes among Hispanic females for January 2000 through December 2010

Figure 8.

Means of pre-May and post-April 2008 error terms from applying pre-Great Recession ARIMA model for older white men to entire test period

Table 1

Means and standard deviations of monthly counts of stroke and other deaths among older (≥ 55 years) Californians by sex and race/ethnicity (n= 132 months starting January 2000 and ending December 2010).

	Stroke Deaths	Other Deaths
White Men	227.5455 (46.6059)	5700.5530 (447.3729)
Black Men	24.3561 (5.4073)	558.5606 (47.5584)
Hispanic Men	45.2424 (7.4158)	1016.0606 (148.4359)
White Women	362.4167 (82.8151)	6197.6894 (581.3567)
Black Women	34.8285 (8.2003)	575.7803 (43.0461)
Hispanic Women	57.5682 (8.8888)	970.6439 (142.4753)

Table 2

Box-Jenkins transfer functions predicting stroke deaths (S_t) among older Californians from deaths by other causes (O_t), a binary Great Recession variable (R_t), and autocorrelation (n = 132 months starting January 2000 and ending December 2010).

Group	Estimated Coefficients
Total Population	$\nabla S_t = -4.7167^{**} + 0.522^{**} \nabla O_t + 5.2435^* R_t + (1-.6726^{**} B)at$
White Men	$\nabla S_t = -1.5019^{**} + .0395^{**} \nabla O_t + 1.9530^* R_t + (1-.7571^{**} B)at$
Black Men	$\nabla S_t = .0417^{**} \nabla O_t + .0048 R_t + (1-.8983 B^{**})at$
Hispanic Men	$S_t = 34.6776^{**} + .0107^* O_t - .0107 R_t + 1/(1+.2153^{**} B)at$
White Women	$\nabla S_t = .0504^{**} \nabla O_t - .2003 R_t + 1/(1+.5857^{**} B)at$
Black Women	$S_t = .0598^{**} O_t - 3.0401 R_t + 1/(1-.3575^{**} B)(1-.2825^{**} B^7)(1-.2325^{**} B^{10})at$
Hispanic Women	$\nabla S_t = .0585^{**} \nabla O_t + .0906 R_t + (1-.8466^{**} B)at$

*
p< .05; 1-tailed test

**
p< .01; 1-tailed test