International Journal of Epidemiology, 2015, 956–966
doi: 10.1093/ije/dyv009
Advance Access Publication Date: 16 June 2015
Original article

Recession and Suicide

Economic downturns and suicide mortality in the USA, 1980–2010: observational study

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Accepted 19 January 2015

Abstract

Background: Several studies have suggested strong associations between economic downturns and suicide mortality, but are at risk of bias due to unmeasured confounding. The rationale for our study was to provide more robust evidence by using a quasi-experimental design.

Methods: We analysed 955 561 suicides occurring in the USA from 1980 to 2010 and used a broad index of economic activity in each US state to measure economic conditions. We used a quasi-experimental, fixed-effects design and we also assessed whether the effects were heterogeneous by demographic group and during periods of official recession.

Results: After accounting for secular trends, seasonality and unmeasured fixed characteristics of states, we found that an economic downturn similar in magnitude to the 2007 Great Recession increased suicide mortality by 0.14 deaths per 100 000 population [95% confidence interval (CI) 0.00, 0.28] or around 350 deaths. Effects were stronger for men (0.28, 95% CI 0.07, 0.49) than women and for those with less than 12 years of education (1.22 95% CI 0.83, 1.60) compared with more than 12 years of education. The overall effect did not differ for recessionary (0.11, 95% CI −0.02, 0.25) vs non-recessionary periods (0.15, 95% CI 0.01, 0.29). The main study limitation is the potential for misclassified death certificates and we cannot definitively rule out unmeasured confounding.

Conclusions: We found limited evidence of a strong, population-wide detrimental effect of economic downturns on suicide mortality. The overall effect hides considerable heterogeneity by gender, socioeconomic position and time period.

Key words: Economic recession, suicide, socioeconomic position, United States

Key Messages

- After controlling for time-invariant state characteristics, common secular trends and seasonality, there is evidence that economic downturns lead to small increases in suicide mortality.
- The effect of economic downturns on suicide did not differ for recessionary vs non-recessionary periods.
- The estimated effect of economic downturns on suicide showed heterogeneity by gender, age, education and time period.

Introduction

There is longstanding interest in studying the relationship between economic conditions and suicide.[1–7] The Great Recession that began in 2007 provides an opportunity to investigate whether rapid economic changes are associated with changes in suicide rates. In both in the USA[8,9] and Europe,[9–13] recent studies of the Great Recession suggest that large changes in economic conditions may have produced important increases in suicide rates, and that governments and institutions should be acting to prevent suicide deaths from economic downturns. However, the extant literature on economic conditions and suicide still suffers from several limitations and remaining questions.

First, the most commonly used measures of economic conditions, such as gross domestic product per capita, are often only available at the country level. However, time-series analyses at the national level may omit factors (e.g. health policies, alcohol consumption) that could be correlated with both macroeconomic changes and suicide.[14] To overcome this problem, previous studies have used state or local variations in economic changes to estimate their impact on suicide rates. This strategy has the advantage of potentially controlling for common (i.e., national) secular trends, but a disadvantage in that studies have often relied on a single indicator (usually the unemployment rate) as proxy for economic conditions.

Second, there exists no work, of which we are aware, that has attempted to quantify heterogeneity of any economic shock-suicide association by socioeconomic position using a quasi-experimental design. There is evidence that economically disadvantaged populations may have been more severely affected by recessions,[15] which suggests that differential effects are plausible. Further, economic recessions may have a more detrimental effect on the mental health of vulnerable populations, including socially disadvantaged groups,[6,16] but direct evidence on this question with respect to suicide is lacking.

Third, most past research has focused on the economic peaks and valleys associated with normal business cycles.[14,17,18] Because 'official' recessions are considered to encompass more severe and widespread changes in macroeconomic conditions, it has been argued that recessions may have larger effects on suicide.[11,19] Whereas there is evidence that larger unemployment increases (<3%) showed stronger effects on suicide than smaller increases in Europe,[20] this has not yet been formally tested.

In this paper we advance the literature on suicide and economic conditions in three ways. First, we take advantage of a broad and comprehensive measure of economic conditions that is local to each US state, rather than relying only on the unemployment rate as a proxy. Second, we extend the analysis of effects on average suicide rates to estimate differential impacts by demographic groups—including socioeconomic position. Third, using both national and state-specific definitions of recession, we test whether the impact of economic conditions on suicide differs during recessionary vs non-recessionary periods.

Methods

Data

We obtained data on suicide deaths by age (15–24, 25–44, 45–54, 65 years and over), gender, race (White, non-White), years of educational attainment (<12 years, 12 years, >12 years), and month for 1980–2010 from the US National Center for Health Statistics Detailed Mortality Files.[21] Combining our four age strata, four gender-race strata, 50 states and 372 months gives a sample size of 297 600. Consistent with previous studies,[22,23] we restricted the education analysis to 45 states with at least 80% completeness of education information in all years in the period from 1994 to 2010 (excluding Georgia, Kentucky, Oklahoma, Rhode Island and South Dakota). We used International Classification of Diseases, 9th revision (ICD-9) codes E950-958 and ICD-10 codes X60-X84 to identify suicide deaths, excluding late effects (E959, Y87.0) that accounted for 0.12% of suicides. We obtained annual population denominators by state and demographic group from the US Census[24] and linearly interpolated monthly population values using annual estimates as benchmarks. We calculated education-specific monthly population estimates from the US Current

Population Surveys by linearly interpolating from annual estimates.[25]

We measured economic conditions using a state-based indicator of current economic activity, the Index of Coincident Economic Indicators (ICEI).[26] Briefly, the ICEI is a monthly composite index of four key indicators of economic activity (private sector employment, the unemployment rate, average weekly work hours of manufacturing workers, and sales tax collections) that is designed to provide a broad index of economic conditions related to wages and labour market activity.[27] Crone reports the median contribution of each component across states as 57.4% for non-farm employment, 17.7% for the unemployment rate, 4.9% for manufacturing hours and 14.3% for real wages and salaries. The ICEI provides a consistent monthly measure of state-level economic output and a similar index has been used previously to study the impact of economic conditions on suicide in New York City,[5] but it has not been applied nationally. Given the evidence that both the magnitude and the timing of recessions in the USA differ by state,[28] the ICEI may provide a better source of identifying variation (compared with, say, pre-recession time trends) for estimating the causal effect of economic conditions on suicide.

Statistical analysis

Identifying the effect of economic downturns on suicide requires the construction of a valid counterfactual 'control group' for estimating what would have happened to suicide rates in the absence of an economic downturn. The control group is critical for accounting for other influences on suicide rates that may be confounded with changes in economic conditions. We used fixed effects regression models to identify the impact of economic conditions on suicide. That is, we estimated the causal effect of economic conditions on suicide by comparing changes over time in suicide mortality within states that experienced larger vs smaller changes in economic conditions. We used a series of Poisson regression models,[29] which assume that the conditional distribution of the number of suicides in state s in month m is Poisson:

$$y_{sm} \sim Poisson(\mu_{sm}).$$

Our general model is written as[30]:

$$\mu_{sm} = exp(\alpha + \beta \times ICEI_{sm} + \sigma_s + \tau_y + \psi_q + \pi_{yq} + \delta \mathbf{X}_{sm} + \ln(pop_{sm}))$$

where μ_{sm} represents the number of suicides in state s in month m, ICEI is the index of economic conditions and we use the log of population size as the offset.[31] This model also includes state fixed effects (σ_s), fixed effects for year (τ_y) and quarter (ψ_q), and their interaction (π_{yq}), and basic demographic covariates $\mathbf{X}_{sm}$ (age, gender, race, education) at the state-month level. We expanded the model above to assess whether the effect of economic downturns is heterogeneous during recessionary periods. For these analyses we included a product term between ICEI and a binary indicator of whether or not a state was in a recession. We used both national recessions as defined by the US National Bureau of Economic Research (NBER)[32] and state-specific recessionary periods. State recessionary periods were defined as a cumulative decline of at least 0.5% in a state's ICEI over a minimum of 3 months.[33] Finally, to present effects on the absolute scale we used the coefficients and standard errors from our Poisson models to estimate marginal predicted incidence rates, rate differences and standard errors using the delta method. We used Stata 13 (StataCorp, College Station, TX) and R 3.1.1 (www.r-project.org) software for data analysis.

The purpose of state fixed effects in the model above is to remove any variation in suicide rates that arises because of time-invariant differences between states (e.g. large and persistent regional variations in US suicide rates). Fixed effects for time are important because there are strong seasonal[34] and national[35] secular trends in suicides. These temporal patterns may be correlated with changes in economic conditions and we do not want to mistakenly identify seasonal changes as being the effect of changing economic conditions. We specified the time effects by including a product term between fixed effects for each year and a series of indicator variables for season, specified quarterly as Nov–Jan, Feb–Apr, May–Jul and Aug–Oct. This allows each quarter of time to have a separate parameter. Flexibly controlling for secular trends also protects our estimates from secular changes in demographic factors that could be correlated with exposure (e.g. changes in the race and gender composition of the labour market). After controlling for state and time fixed effects, we use residual variation in the timing and severity of changes in economic conditions across states to estimate the effects on suicide. That is, when a state's change in economic output is greater (or less) that the national average, we use that variation to identify the effect of economic changes on suicide rates.

In addition to the fixed effects for year-season, we also estimated models including state-specific linear, quadratic and cubic time trends. The purpose of these models is to attempt to control for residual confounding by unmeasured state characteristics that would, for example, lead to suicide rates gradually trending differently in states with different trends in economic conditions.[36] We also estimated

each of these models separately for demographic subgroups by age, gender and education and tested for heterogeneity across subgroups using Cochran's Q statistic.

As a series of checks on our main fixed effects models, we also conducted several sensitivity analyses. We estimated: (i) models with 6- and 12-month lagged values of ICEI; (ii) negative binomial models as a check on the Poisson assumption that the conditional mean and variance are equal; (iii) models with the seasonally-adjusted unemployment rate rather than ICEI as a measure of exposure; (iv) models using cancer mortality as a negative control outcome for detecting bias; and (v) estimates for different periods of observation.

All of the publicly available data and statistical code for reproducing the results in this study are available with unrestricted open access from the corresponding author's Dataverse: http://dvn.iq.harvard.edu/dvn/dv/samharper.

Results

Figure 1 shows the change in the mean ICEI over the previous three decades (indexed to a value of 100 in July 1992), overlaid with recessionary periods as defined by the NBER.[32] During non-recessionary periods, the ICEI grew by an average of about 2.5% per month, whereas during recessions it declined by about 2.7% per month. The average absolute decline in ICEI during recessionary periods was roughly four points. During the Great Recession (December 2007 to June 2009), the value of the ICEI plummeted by 8%, from 160.9 to 148.1. To facilitate interpretation of our regression results, we use a similar change in the ICEI (10 points) when estimating exposure contrasts. Figure 1 also shows state-specific changes (blue lines) in ICEI from 1980 to 2010 and demonstrates heterogeneity by state, as it is clear that economic conditions began declining in some states both before and after the onset of the national recession.

From 1980 to 2010 there were 955 561 suicides (see Appendix Table 1 for number of suicides and crude suicide rates by demographic groups, available as Supplementary data at *IJE* online). Figure 2 shows temporal trends in the crude suicide mortality rate by gender, age group, race and education, in addition to loess-smoothed trends (bandwidth = 0.25). The figures readily demonstrate strong seasonality among all groups and persistently higher rates of suicide among men, Whites and those with 12 or fewer years of education. The age patterning of suicide rates has changed considerably during past decades. Most notably, suicide rates among those aged 65 and over have dropped steadily since the mid 1980s, whereas the rates among those aged 45–64 years have increased since the early 2000s. Each graph also shows shaded regions

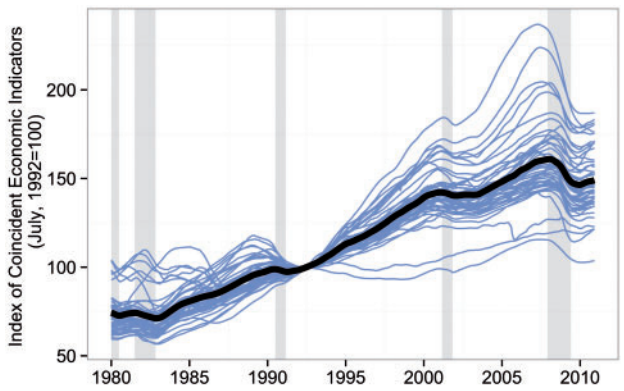

Figure 1. Mean monthly Index (July 1992 = 100) of monthly Coincident Economic Indicators for each state (thin blue lines) and national average (thick black line), 1980–2011. Shaded areas indicate recessionary periods as defined by the National Bureau of Economic Research[32].

corresponding to periods of national economic recession as defined by NBER.[32]

Table 1 shows results from our regression models. With respect to demographic factors, our estimates show higher suicide rates among men, those aged 65 and over, Whites, and in spring and summer relative to winter. With adjustment for demographic covariates and state and year-season fixed effects, a 10-unit decrease in the ICEI was associated with an increase of 0.14 suicide deaths per 100 000 population (95% CI 0.0, 0.28), which translates roughly into a 1% increase. Additional models controlling flexibly for non-linear time trends that may vary across states that experienced differential changes in economic conditions were somewhat larger than the basic fixed effects model, but with considerable overlap of confidence intervals.

Figure 3 shows results from additional models investigating heterogeneity of the effects of economic conditions on suicide. The estimate at the top is from the fixed effects model for the overall effect on suicide mortality (Model 2 in Table 1). The next estimates are from an expanded model that allowed the effect of economic conditions on suicide to vary by recessionary period. We found little evidence that the impact of economic changes on suicide differs during 'official' recessions (Cochran's $Q = 0.82$, $p = 0.85$), whether defined at the national or at the state level. Figure 3 also shows estimates of the effects of changes in economic conditions on suicide separately for each demographic group, including education (limited to ages 25 and over, when educational attainment is usually complete), and there is some evidence of heterogeneity (model results for each demographic group are shown in Appendix Table 2, available as Supplementary data at *IJE* online). Our estimates show that a 10-unit decrease in the ICEI increased suicide mortality by 0.28 deaths per 100 000 population (95% CI 0.07, 0.49) among men but

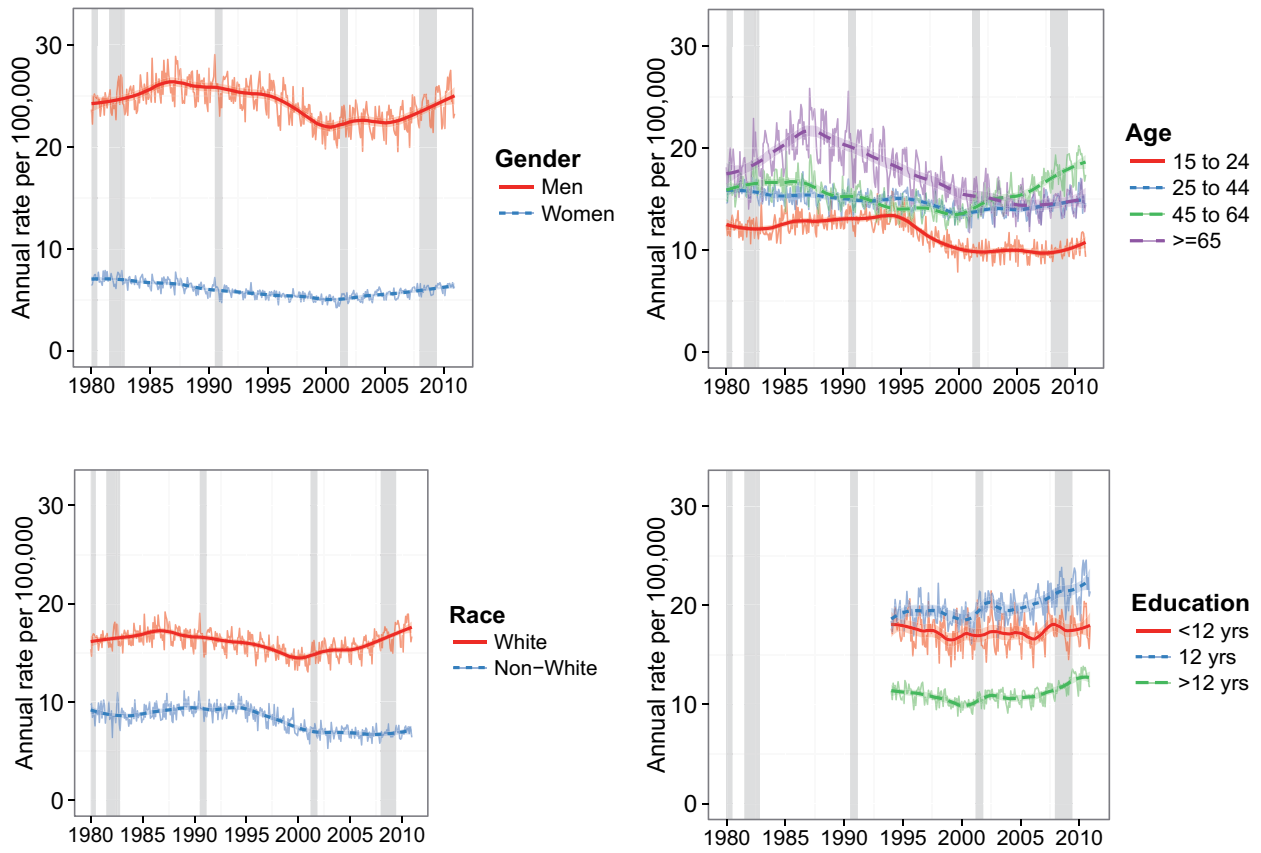

Figure 2. Temporal trends in suicide mortality by gender, age, race and education, by month, 1980 to 2010. Estimates for education are for individuals ages 25 and older. Darker lines are loess-smoothed conditional means (band width = 0.25). Shaded areas indicate national recessionary periods as defined by the National Bureau of Economic Research.[32] Estimates for education are for 45 states that report education on 80% of death certificates (excluding Georgia, Kentucky, Oklahoma, Rhode Island and South Dakota).

had no effect on women (0.02, 95% CI −0.06, 0.09, Cochran's $Q = 5.34$, $p = 0.02$), though for the latter group estimates with state-specific trends suggested effects around 0.1 deaths per 100 000 population. Effects were generally similar by race ($Q = 0.71$, $p = 0.40$) but differed by age group ($Q = 15.56$, $p = 0.001$), though heterogeneity by age was driven by a protective effect among those aged 65 and over (−0.15, 95% CI −0.30,−0.00). Our estimates for education groups were limited to 45 states from 1994 to 2010, and Figure 3 also shows that the effect of economic downturns was somewhat larger in this period (0.35 deaths per 100 000) relative to the entire period from 1980 to 2010. More strikingly, the estimates by education group show that the overall effect in this period masks considerable heterogeneity ($Q = 26.96$, $p < 0.001$). We estimate that large economic downturns increased suicide mortality by 1.22 deaths per 100 000 population (95% CI 0.83, 1.60) among those with <12 years of education, compared with only 0.17 (95% CI 0.03, 0.30) among those with >12 years of education. Estimates by education were similar when limited to those aged 25–64.

Table 2 shows results from additional sensitivity analyses; 6- and 12-month lagged effects of ICEI were nearly identical to the contemporaneous effect. A fixed effects negative binomial model showed that there was some overdispersion in the Poisson model (alpha = 0.038, 95% CI 0.030, 0.49), but marginal effects and standard errors were also nearly identical to the Poisson model. We found no evidence of an effect of economic conditions using cancer mortality as the outcome (see Appendix Table 3 for full model results, available as Supplementary data at *IJE* online), indicating that our effect estimates are not being driven by other state-specific time-varying factors that might affect mortality more generally. Using the seasonally adjusted unemployment rate rather than ICEI was not associated with suicide mortality in the basic two-way fixed effects model; however, estimates with state-specific trends (see Appendix Table 4, available as Supplementary data at *IJE* online) were consistent with an increase of roughly 0.5 suicide deaths per 100 000. Lastly, estimates by period varied to some degree, with stronger effects evident when the base year of analysis was the 1990s.

Table 1. Rate difference (RD) per 100,000 person-years, and 95% CI, for the effect of changes in the Index of Coincident Economic Indicators (ICEI) on suicide mortality rates among those aged 15 years and over, USA 1980–2010

	Model 1		Model 2		Model 3		Model 4		Model 5	
	RD	95% CI	RD	95% CI	RD	95% CI	RD	95% CI	RD	95% CI
ICEI (10-unit decrease)	0.13	(−0.02, 0.28)	0.14	(0.00, 0.28)	0.18	(0.08, 0.28)	0.19	(0.06, 0.31)	0.29	(0.12, 0.45)
Women vs men	−15.45	(−16.52, −14.38)	−16.91	(−18.08, −15.75)	−16.87	(−18.03, −15.70)	−16.87	(−18.03, −15.70)	−16.87	(−18.03, −15.70)
Non-Whites vs Whites	−7.87	(−8.81, −6.93)	−8.48	(−9.39, −7.57)	−8.43	(−9.34, −7.52)	−8.43	(−9.33, −7.52)	−8.43	(−9.34, −7.52)
Age (years)										
25–44 vs 15–24	2.72	(2.34, 3.10)	3.01	(2.66, 3.36)	3.00	(2.66, 3.35)	3.01	(2.66, 3.35)	3.01	(2.66, 3.35)
45–54 vs 15–24	3.51	(2.66, 4.35)	3.92	(3.09, 4.76)	3.91	(3.09, 4.73)	3.91	(3.09, 4.73)	3.91	(3.09, 4.73)
65+ vs 15–24	6.03	(4.64, 7.41)	6.66	(5.24, 8.08)	6.64	(5.24, 8.04)	6.64	(5.24, 8.04)	6.64	(5.24, 8.04)
Season										
Feb–Apr vs Nov–Jan			1.17	(1.03, 1.31)	1.13	(0.99, 1.26)	1.12	(0.99, 1.26)	1.12	(0.99, 1.26)
May–Jul vs Nov–Jan			1.14	(1.01, 1.27)	1.21	(1.08, 1.35)	1.21	(1.08, 1.35)	1.21	(1.08, 1.35)
Aug–Oct vs Nov–Jan			0.35	(0.15, 0.55)	0.53	(0.36, 0.70)	0.53	(0.36, 0.70)	0.53	(0.36, 0.70)
Fixed effects:										
Year × season		No		Yes		Yes		Yes		Yes
State		No		Yes		Yes		Yes		Yes
State-specific linear trends		No		No		Yes		Yes		Yes
State-specific quadratic trends		No		No		No		Yes		Yes
State-specific cubic trends		No		No		No		No		Yes

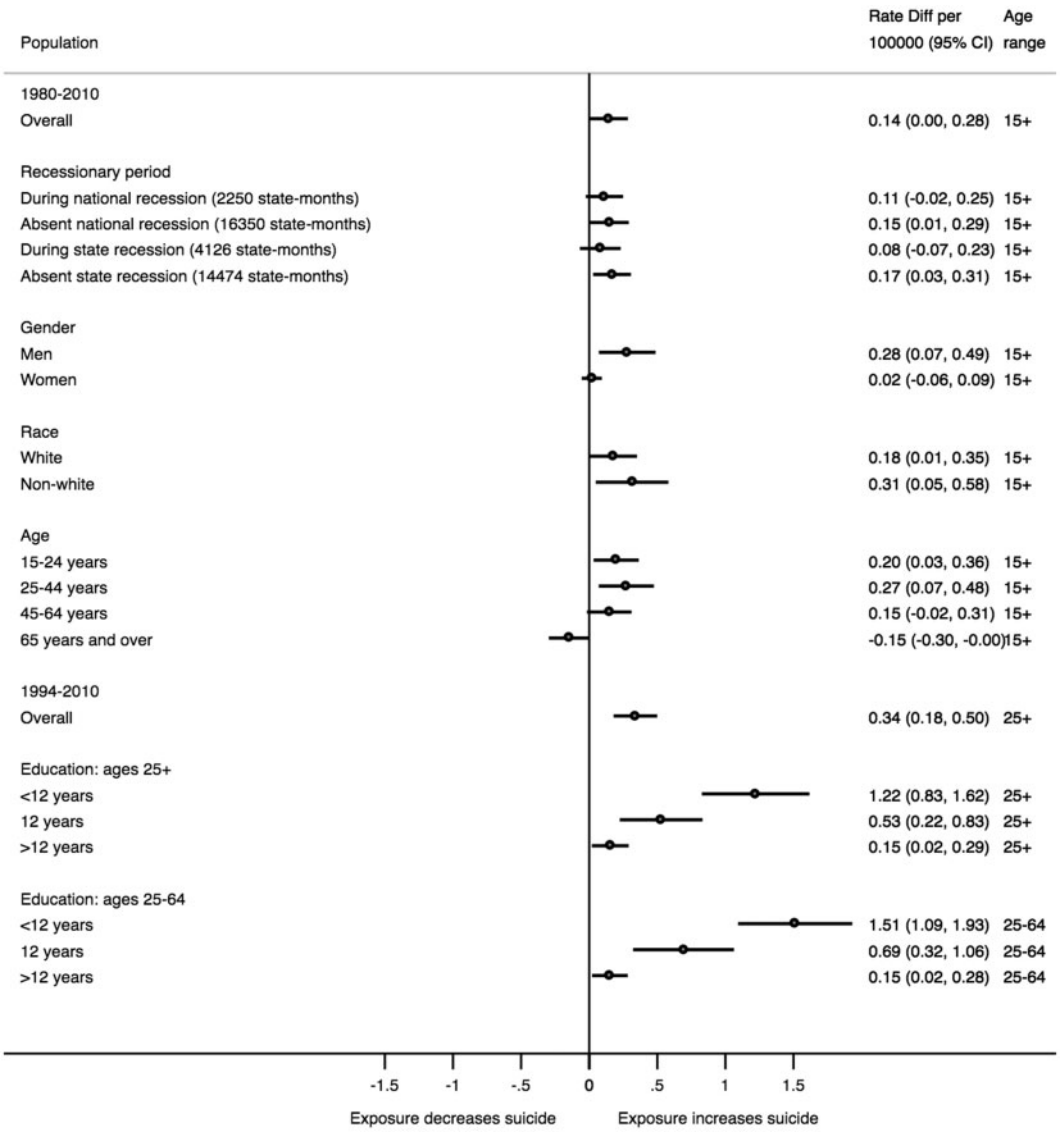

Figure 3. Estimated effect of 10-point decrease in the Index of Coincident Economic Indicators on suicide mortality, by recessionary period and demographic group. Effects for each demographic group were estimated in separate models that controlled for other demographic factors, state fixed effects and quarter fixed effects (specified as a set of product terms between year and season of death).

Interestingly, restricting only to the period including the Great Recession (2005–10) produced generally null effects, regardless of whether we used the ICEI [rate difference (RD) = 0.0, 95% CI −0.12,0.12, Table 2] or the unemployment rate (RD = 0.12, 95% CI −0.13, 0.38).

Discussion

A recent systematic review of the health effects of recessions noted that the 'most consistent results' between recessions and mortality are for suicide.[6] Although this review suggests that there is little controversy regarding a correlation between economic conditions and suicides, our analysis suggests that any population-wide causal effects in the USA may be smaller than previously estimated. Both Chang *et al.*[9] and Reeves *et al.*[8] estimated that approximately 4500 'excess' US suicides had occurred between 2007 and 2010, and the latter study attributed about 1500 of these to the change in the unemployment rate during the Great Recession. Our results do not correspond directly to the estimates of 'excess deaths' due to recessions, since we are only isolating the effect of economic fluctuations rather than the entire scope of changes that occur during recessionary periods. However, with respect to economic fluctuations, our estimates are about one-third of the magnitude of previous estimates. For a reduction in ICEI equivalent to

Table 2. Sensitivity analyses for the effect[a] of a 10-unit decrease in the Index of Coincident Economic Indicators (ICEI) on suicide mortality rates, 1980–2010

Model adjustments[b]	Rate difference per 100 000 person-years	95% CI
Basic fixed effects model		
ICEI (Model 2 from Table 1)	0.14	0.00, 0.28
Lagged effects		
Fixed effects using 6-month lagged ICEI	0.14	−0.00, 0.27
Fixed effects using 12-month lagged ICEI	0.13	−0.01, 0.27
Alternative specification		
Negative binomial regression	0.13	−0.02, 0.27
Negative control outcome		
Cancer mortality	−0.03	−3.08, 3.03
Alternative exposure		
Unemployment rate as exposure (9.6% vs 5.8%)	−0.08	−0.62, 0.46
Effects by period of analysis		
1985–2010	0.15	0.02, 0.29
1990–2010	0.18	0.04, 0.32
1995–2010	0.22	0.11, 0.32
2000–10	0.07	0.01, 0.14
2005–10	0.00	−0.12, 0.12

[a]Marginal effect from Poisson regression.
[b]All models also adjust for age, gender, race, season-by-year fixed effects and state fixed effects.

that during the Great Recession (160.8 to 148.1), we estimate 0.18 (95% CI 0.01, 0.28) more suicide deaths per 100 000 population. For a population ages 15 and over of around 250 million, this equates to about 450 excess deaths (95% CI 25, 850). What accounts for the difference? Earlier studies of excess suicides during the Great Recession relied on extrapolation of age-standardized secular trends in suicide during the early 2000s to estimate the counterfactual suicide rate in the absence of a recession. These 'time-trend' designs may be susceptible to bias, either by misspecification of 'counterfactual trends' or by confounding by other potential determinants of suicide rates that are correlated with the timing of the recession.[13,37] Our estimates, in contrast, use larger vs smaller changes in economic conditions within states to estimate the impact on suicide mortality, thus purging our estimates of any non-linear trends in suicide that are common among all states. A recent study[13] in the UK also concluded that previous estimates[11] in that population, which also relied to some extent on linear extrapolation, may have been confounded by non-linear suicide trends.

To be clear, our estimates are consistent with an increase in suicide mortality following an economic downturn. However, the increase in suicide is only around 0.4% for the change in economic conditions during the average recession (a decline in ICEI around 3%) and, even for a change as large as the Great Recession, the increase in suicide is roughly 1%. These effects should be seen in context of other factors affecting suicide rates. Quasi-experimental studies on drunk driving laws and alcohol consumption have shown effects on suicide of 10–15% among young people;[38,39] similarly designed studies of divorce laws reported effects of around 10% among women.[40] Moreover, according to our estimates the number of excess suicide deaths in May–June relative to Oct–Dec every year is nearly 3000 (RD approximately 1.2 per 100 000), almost seven times greater than the excess death rate attributable to the economic fluctuations accompanying the Great Recession. This does not mean that the impact of economic fluctuations on suicide should be ignored, but excess deaths associated with changing economic conditions should be put in the context of larger social and economic trends that may be stronger determinants of changes in suicide rates. Although not a substitute for quantitative estimates, visual inspection of suicide rates over time among demographic groups (Figure 2) are also not suggestive of strong recessionary effects. For example, rates of suicide among middle-aged individuals have been rising steadily since the early 2000s, though the precise causes are unknown.[41] Likewise, rates among youth began trending downward in the mid 1990s and flattened out in the 2000s, and rates among those aged 65 years and over decreased strongly after the mid 1980s. Suicide mortality rates thus exhibit strong seasonality and

demographic-specific trends, but these show little evidence of being disrupted by shifts in either intercept or slope during economic downturns, even during the Great Recession.

We also found some evidence that the overall impact of economic changes on suicide mortality masks an unequal distribution across social groups. In particular, we found that the effect was concentrated among men, middle-aged groups and those with the lowest education. In some respects these differential effects accord well with the groups that have been hardest hit by recessions. In percentage point terms, the Great Recession's effects on unemployment were strongest among the very young (16–20-year-olds), Blacks and Hispanics, and those with less than a high school degree,[15] and to some extent we find that the adverse effect of economic conditions on suicide mortality were largest in those groups. The stronger impact of economic changes on suicides among middle-aged groups is consistent with some previous work,[6,42] as is the lack of evidence for negative impacts of recessions on older adults.[42–44]

Our finding of stronger effects among the lowest educated is novel, as prior investigations have not disaggregated the effect by socioeconomic position. This effect seems consistent with a general picture of worsening relative mortality among those with low education in the USA in recent years.[22,45,46] Meara *et al.* found that educational differences in life expectancy widened between 1981 and 2000, though they attributed a good deal of this increase in inequality to smoking-related diseases.[45] Because suicide is generally rare and economic recessions are infrequent, it seems unlikely that recession-induced suicide mortality has played a large role in widening socioeconomic gaps in life expectancy. However, the general economic stagnation experienced by low-educated individuals in the USA in recent years[47] could be concentrating suicide among lower-educated groups.

Prior work has also suggested that the impact of economic conditions on suicide mortality may be stronger in the context of large changes in unemployment.[19,20] Recessionary periods typically demonstrate much larger increases in unemployment relative to seasonal or annual fluctuations. We tested whether any effect of economic fluctuations on suicide differed during recessionary periods, but found little evidence of any difference during periods of either 'official' national recessions or our categorization of recessions for each state. The argument that more severe recessions have stronger effects on suicide also conflicts with our estimates restricted to the most recent period, encompassing the Great Recession (2005–10). When restricting to this period, we found generally null effects, regardless of the measure of economic conditions.

Our analysis has limitations. We used an unconditional fixed effects Poisson model with robust variance and found that suicide mortality rates were overdispersed, but a negative binomial model produced similar results, and unconditional fixed effects Poisson models are not subject to the incidental parameters problem.[29,30] We did not adjust for changes in ICD coding, but the comparability ratio for the same US suicide deaths coded under ICD-9 and ICD-10 is reported as 0.996, suggesting minimal misclassification.[48] We also assumed no differential classification of suicide deaths by state. There is some evidence of regional differences in suicide reporting,[49] but it seems unlikely that it may correlate with the timing of economic downturns across states. The coding of education on death certificates was revised in 2003 to reduce missing data, but not all states have adopted the revised version.[50] This could affect suicide rate differences by education, but state and time fixed effects make this unlikely as a source of bias in our effect estimates. Finally, our models assume there are no unmeasured factors that are correlated with both economic conditions and suicide rates in a time-varying way. Our use of fixed effects models removes concern for time-invariant state characteristics and national trends, but we obviously cannot rule out the possibility that unmeasured factors that vary over time and by state could have biased our estimates.

In summary, using a comprehensive state-based measure of economic conditions we find some evidence that worsening economic conditions increase suicide mortality. The effects are heterogeneous across age, gender and education groups, and are sensitive to choices about the period of observation and how underlying trends in suicide are modelled. Future research should focus on better understanding the role of separate components of the ICEI and related economic factors that change during economic downturns, and on eliciting the mechanisms by which economic fluctuations may increase suicide among socioeconomically disadvantaged young men.

Supplementary Data

Supplementary data are available at *IJE* online.

Funding

This work was supported by Canadian Institutes of Health Research Operating Grants #120314 and #115214. S.H. was supported by a Chercheur-boursier Junior 2 from the Fonds de recherche du Québec - Santé (FRQS). E.C.S. was supported by a Chercheur-boursier Junior 1 from the Fonds de la Recherche du Québec – Santé and the Ministére de la Santé et des Services sociaux du Québec. A.N. was supported by the Canada Research Chairs programme.

The sponsors had no role in the design, data collection, analysis, interpretation of data or writing of the article, nor in the decision to submit it for publication.

Conflict of interest: All authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare no competing interests.

Details of contributors

All authors contributed to the conception, critical review, study design and data interpretation. T.J.C. and S.H. performed the analysis. S.H. produced the first draft, with revision for important intellectual content by T.J.C., E.C.S., S.G. and A.N. All authors approved the final version. S.H. is the guarantor. All authors affirm that the manuscript is an honest, accurate and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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Commentary: On the use of quasi-experimental designs in public health evaluation

International Journal of Epidemiology, 2015, 966–968
doi: 10.1093/ije/dyv065
Advance Access Publication Date: 16 June 2015

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Accepted 19 January 2015

Quasi-experimental designs are often applied in public health research to assess phenomena for which truly experimental studies are not feasible. Recently, investigators have used these tools to examine the association between macro-economic conditions and rates of suicides in specific populations.[1–3] In this issue of the *International Journal of Epidemiology*, Harper and colleagues have added new evidence to this topic, with an analysis on a large dataset including more than 20 years of data and almost 1 million cases in the USA.[4] The original analytical approach they propose, combined with the interpretational issues in evaluating such a complex multi-factorial phenomenon, provide an excellent opportunity to comment on the benefits and limitations of quasi-experimental designs in public health evaluation studies.

The first issue we would like to discuss pertains to the definition of the research question. This step is straightforward in experimental analyses such as randomized controlled trials, in which the treatment is directly allocated to an intervention group, and a specific health outcome is then measured and compared with a control group. This makes the objective of the analysis, and the scope of the