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Original Contribution

Economic Conditions and Suicide Rates in New York City

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Extant analyses of the relation between economic conditions and population health were often based on annualized data and were susceptible to confounding by nonlinear time trends. In the present study, the authors used generalized additive models with nonparametric smoothing splines to examine the association between economic conditions, including levels of economic activity in New York State and the degree of volatility in the New York Stock Exchange, and monthly rates of death by suicide in New York City. The rate of suicide declined linearly from 8.1 per 100,000 people in 1990 to 4.8 per 100,000 people in 1999 and then remained stable from 1999 to 2006. In a generalized additive model in which the authors accounted for long-term and seasonal time trends, there was a negative association between monthly levels of economic activity and rates of suicide; the predicted rate of suicide was 0.12 per 100,000 persons lower when economic activity was at its peak compared with when it was at its nadir. The relation between economic activity and suicide differed by race/ethnicity and sex. Stock market volatility was not associated with suicide rates. Further work is needed to elucidate pathways that link economic conditions and suicide.

economic recession; economics; longitudinal studies; mental health; New York City; suicide

Abbreviations: AIC, Akaike information criterion; GAM, generalized additive model; ICEI, index of coincident economic indicators; NYC, New York City.

Globally, approximately 1 million people per year commit suicide (1). A recent review in which risk factors for suicide were summarized showed a focus on studies assessing proximal characteristics, including psychiatric morbidity and history of self-harm (2), which are present in approximately 90% and 40% of individuals who commit suicide, respectively (3). Genetic factors (4), exposure to childhood adversities and stressful life events (5, 6), access to means of committing suicide (e.g., access to firearms or prescription drugs) (7, 8), and poorer physical health (9) are also associated with suicide.

Rates of suicide death exhibit substantial variability, both within places over time and across geographic regions, at different scales (10–18). Although proximal risk factors contribute to our understanding of the factors that predict individual-level vulnerability to suicide, they are unlikely to explain observed spatiotemporal variability in rates of suicide. As noted by Emile Durkheim in his seminal work *Suicide* (19), the determinants of individual cases of suicide might be distinct from the determinants of the suicide rate, a social attribute that Durkheim considered a new fact sui generis. From a population-health perspective, variability in the rate of suicide might reflect changes in exposure to intermittent stressors that occur within populations (20), including instability in the economic cycle (19, 21, 22).

A growing body of empirical work has considered how economic conditions are associated with mortality. Although some research has indicated that economic downturns and rapid economic change adversely affect health (23–25), recent econometric analyses showed that economic expansions are associated with increased mortality rates and shorter life expectancies at the population level (26–32), resulting in the counterintuitive conclusion that recessions are ''good for your health'' (33, 34). A notable exception is

suicide. Work investigating the relation between economic conditions and suicide generally shows that rates of suicide tend to fluctuate countercyclically with economic activity, increasing during recessions and economic downturns (21, 28, 29, 33, 35–40). However, findings have been inconsistent; for example, suicide rates fluctuated countercyclically in some countries during the Asian financial crisis of the late 1990s (35–37) but remained stable or declined during a recession in Finland in the early 1990s (41, 42). Alternative methodological approaches for handling challenges to internal validity may contribute to mixed findings.

One of the primary challenges to research concerning economic conditions and health is confounding. Most studies are based on parametric modeling of annualized data and may not adequately account for measured and unmeasured time-varying confounders, potentially resulting in biased estimates of the association between economic conditions and suicide. For example, seasonal and long-term secular trends, such as levels of spending on mental health services, may confound the association between economic conditions and suicide rates. The application of nonparametric alternatives such as generalized additive models (GAMs), which account for potential time-varying confounding using smoothing functions, to data of finer temporal resolution offers a flexible alternative to the traditional approach. A second threat is measurement error. Economic conditions are generally measured using gross domestic product, an important economic indicator that nonetheless may be removed from the everyday experience of individuals. Alternative measures, such as levels of employment, hours worked, consumer confidence, and stock market volatility, might more adequately capture the economic insecurity experienced by populations during times of economic crisis (40, 43).

In light of these challenges, we explored the use of GAMs applied to historical economic and suicide data from New York City (NYC) to estimate the relation between economic conditions, measured by economic activity and volatility in the stock market, and monthly rates of suicide. Furthermore, as data from recent studies have suggested that the method of death (44) and demographic characteristics, including sex (45) and age (46), may moderate the relation between levels of economic activity and suicide, we assessed whether the relation between economic conditions and suicide rates varied according to the type of suicide (i.e., violent vs. nonviolent) and individual-level demographic characteristics (i.e., age, sex, or race/ethnicity).

MATERIALS AND METHODS

Data collection

Our primary outcome variable was the monthly rate of suicides among NYC residents between 1990 and 2006. We determined the number of suicides that occurred in NYC between 1990 and 2006 through manual review of medical files at the Office of the Chief Medical Examiner of NYC. The Office of the Chief Medical Examiner reviews all deaths presumed to have occurred in an unnatural manner and uses autopsy findings, toxicology reports, and details relating to the circumstances of death to attribute a primary cause of death to each fatality. Consistent with prior research (47–50), we categorized suicides by drug overdose, gassing, or poisoning as nonviolent and all others as violent. Sociodemographic characteristics of each decedent, including age (categorized as <25, 25–44, 45–64, or >64 years), sex, and race/ethnicity (dichotomized as white or nonwhite), were also collected.

Economic conditions were measured using an indicator of current economic activity in New York State and the degree of volatility in the New York Stock Exchange. We used the Index of Coincident Economic Indicators (ICEI), available from the New York State Department of Labor, to measure the level of economic activity in the New York region. Briefly, the ICEI is a monthly composite index of 4 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 information about the economic conditions of New York State. The ICEI has been shown to be a reliable historical measure of current economic functioning in New York; the New York State Department of Labor reports that a decline in the ICEI for 5 consecutive months has predicted a recession in New York State in every instance over the past 40 years. Further details concerning the ICEI have been published elsewhere (51). We used data on the daily New York Stock Exchange closing price (52) to calculate stock market volatility based on the method developed by French et al. (53). Briefly, monthly stock market volatility was calculated as the square root of the sum of the squared difference between the daily closing price and the average closing price for the month divided by the daily closing price. Monthly estimates of volatility included only days when the New York Stock Exchange was open, and all monthly values were log transformed.

Statistical analyses

Total and age-, sex-, and race-stratified population estimates for NYC from 1990 to 2000 were obtained from the US Census and used to linearly interpolate and extrapolate values for years from 1991 to 1999 and 2001 to 2006 (54, 55). We calculated total and age-, sex-, and race-stratified monthly rates of suicide among NYC residents from 1990 through 2006. We estimated the influence of the economic environment on suicide rates using nonparametric GAMs, assuming a Poisson distribution. In contrast to fully parametric regression methods, GAMs use parameters known as smoothing functions. Smoothing functions facilitate examination of nonlinear associations between variables because the relation of the predictors to the outcome is derived solely from the data and not established a priori. The smoothing functions (denoted by $s(\bullet, \lambda)$ below, where λ represents the degrees of freedom) for each variable were calculated using penalized regression. Specifically, we used a univariate cubic spline as the base and generalized cross-validation to determine the appropriate amount of smoothness (56, 57). The posterior distributions of the model coefficients were used to calculate 95% confidence intervals. We then used unpenalized regression to obtain robust P values of the independent variables, assuming the same degrees of freedom from the penalized regression (56).

We ran a series of nested GAMs, selecting a preferred model specification by comparing the Akaike information criterion (AIC) across models. The AIC is a measure of relative goodness of fit, with lower values indicative of better model fit. In the first model (AIC = 1,445.7), we assessed the unadjusted relation between the ICEI and the rate of suicide and found evidence of a significant nonlinear association between the ICEI and suicide rates ($P < 0.01$). In the second model, we added our measure of stock market volatility; in that model (AIC = 1,451.9), both the ICEI and stock market volatility were nonlinearly associated with suicide rates ($P < 0.01$ for both). In the third model, we accounted for potential confounding by long-term trends using a continuous count for each month that ranged from 1 to 204 (58, 59) and seasonal time trends using an indicator for the month of the year that ranged from 1 to 12 (49, 60, 61). In the third model (AIC = 1,382.3), the significant nonlinear association between the ICEI and the rate of suicide persisted after adjustment for long-term and seasonal time trends ($P < 0.01$); however, stock market volatility was no longer associated with suicide. Finally, we ran a fourth model (AIC = 1,380.42) that omitted stock market volatility:

$$\log\left(E\left[Y_t\right]\right) = \alpha + s_1\left(\mathrm{ICEI}_t, 2.11\right) + s_2\left(\mathrm{time}_{\mathrm{long}}, 2.42\right) + s_3\left(\mathrm{time}_{\mathrm{season}}, 2.65\right) + \log\left(N\right) + \varepsilon.$$

In this final model, $\log(E[Y_t])$ represents the log expected number of suicides in New York City in month t, $s_1(\mathrm{ICEI}_t)$ represents a smooth function of economic activity measured by the ICEI with 2.11 degrees of freedom, $s_2(\mathrm{time}_{\mathrm{long}}, 2.42)$ represents a smooth function of long-term time trends with 2.42 degrees of freedom, $s_3(\mathrm{time}_{\mathrm{season}}, 2.65)$ represents a smooth function of seasonal time trends with 2.65 degrees of freedom, and N represents the midyear population of NYC for each year from 1990 to 2006 (62).

We assessed whether the association between the economic environment and the rate of suicide varied by suicide type. We assessed interaction using an approximate test for symmetry of splines in nonparametric modeling, as described elsewhere (56, 63). Briefly, we ran a nonparametric model with 2 cubic splines for ICEI based on the type of completed suicide (violent or nonviolent) and then compared the model fit (chi-squared) of this model to a semiparametric model with one spline for ICEI and a parametric coefficient to identify the main effect of the type of suicide (value of 0 or 1). As a second method, we ran our analyses stratified by suicide type and inspected the association between the ICEI and suicide visually. We used similar methods to assess whether age, sex, or race/ethnicity modified the relation between the ICEI and the number of suicides.

We assessed the sensitivity of our findings to the selection of a nonparametric modeling strategy by comparing our final results with those from a generalized linear model with natural cubic splines (64, 65), a fully parametric alternative in which we used the same specification as above. Results from the generalized linear model (Web Figure 1, available at http://aje.oxfordjournals.org/) were qualitatively similar to results from the fourth model above, and below we present results from nonparametric models. All models were run using the statistical software R (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

There were 8,068 suicide deaths among residents of NYC between 1990 and 2006. Rates of suicide per 100,000 residents in NYC between 1990 and 2006 are presented in Table 1. Overall rates of suicide declined linearly from 8.1 per 100,000 people in 1990 to 4.8 per 100,000 people in 1999 and then remained relatively stable from 1999 through 2006. Longitudinal trends stratified by sex, age, and race are shown in Figure 1.

The results from our final GAM showing the association between the ICEI and the monthly rate of suicides per 100,000 NYC residents with smoothing functions to account for time trends are shown in Figure 2. There was a negative association between rates of suicide and the ICEI at values greater than 105, indicating that rates of suicide in NYC were lowest when economic activity was greatest.

We assessed the strength of the association between the ICEI and suicide rate by comparing rates of suicide at different values of the ICEI. On the basis of the posterior distribution of the parameters in our model, the predicted monthly rates of suicide per 100,000 persons were 0.54 (standard deviation = 0.03), 0.50 (standard deviation = 0.01), and 0.42 (standard deviation = 0.02) when the ICEI was at its lowest value of 99.8, its median monthly value of 108.9, and its highest value of 115.5, respectively (Table 2). This translated to a mean difference of −0.12 per 100,000 persons when comparing the predicted rate of suicide in a month when the ICEI was at its peak with that when the ICEI was at its nadir.

Web Figures 2–4 show results from our final GAM stratified by race/ethnicity, sex, and age, respectively. There was evidence that the association between ICEI and suicide varied by race/ethnicity, sex, and age, although the P value for the chi-squared test assessing interaction was less than 0.05 for race/ethnicity and sex but not age. The rate of suicide declined monotonically among whites, men, and adults less than 45 years of age as the ICEI increased from its nadir of 99.8 to its peak of 115.5. In contrast, there was evidence of nonlinear associations between the ICEI and rates of suicide for nonwhites, women, and adults 45 years of age or older, for whom the greatest rates of suicide were observed when the ICEI approached values of 107, 105, and 104, respectively. Predicted monthly rates of suicide at the lowest, median, and peak values of the ICEI from GAMs that accounted for time trends are shown in Table 2 for whites, nonwhites, men, women, adults less than 45 years of age, and adults 45 years of age or older.

DISCUSSION

The current economic crisis has invigorated interest in the relation between the economic environment and suicide rates and prompted some to forewarn of increased rates of economically induced suicides (66) or ''econocide,'' a term that was recently coined by American psychologists (67). Although

Table 1. Number and Rate of Total, Violent, and Nonviolent Suicide Deaths[a] Among New York City Residents by Year ($n = 8,068$), 1990–2006

Year	Total ($n = 8,068$)[b]		Violent ($n = 6,673$)		Nonviolent ($n = 1,393$)	
	Total No. of Suicides	Rate per 100,000 NYC Residents	Total No. of Suicides	Rate per 100,000 NYC Residents	Total No. of Suicides	Rate per 100,000 NYC Residents
1990	596	8.1	471	6.4	124	1.7
1991	612	8.3	496	6.7	116	1.6
1992	574	7.7	453	6.1	121	1.6
1993	511	6.8	422	5.6	89	1.2
1994	550	7.3	453	6.0	97	1.3
1995	516	6.8	433	5.7	83	1.1
1996	480	6.2	395	5.1	85	1.1
1997	458	5.9	380	4.9	78	1.0
1998	459	5.8	397	5.1	62	0.8
1999	381	4.8	322	4.1	58	0.7
2000	386	4.8	333	4.2	53	0.7
2001	400	5.0	334	4.1	66	0.8
2002	447	5.5	376	4.6	71	0.9
2003	424	5.2	359	4.4	65	0.8
2004	439	5.4	372	4.6	67	0.8
2005	419	5.1	336	4.1	83	1.0
2006	416	5.0	341	4.1	75	0.9

Abbreviation: NYC, New York City.

[a] Suicides by drug overdose, gassing, or poisoning were considered nonviolent; all others were considered violent.

[b] The sum of violent and nonviolent suicides was less than the total number of suicides because cause of suicide was not specified for 2 suicide decedents.

vital statistics for the period covering the current recession are unavailable, historical data provide an opportunity to predict the influences of current and future recessions on patterns of suicide. Using data on monthly counts of suicides in NYC from 1990 through 2006 to assess the time-series relation between levels of economic activity, stock volatility, and suicide, we found that economic activity was negatively associated with suicide. The relation between economic activity and suicide differed by race/ethnicity and sex.

A growing body of international research has shown that rates of suicide in particular and mental health in general are associated with economic activity. With the exception of Finland, which experienced an increase in suicide during an economic upswing between 1985 and 1990 and a decline during a subsequent period of recession (42), there are few empirical examples of suicide increasing during times of economic prosperity, challenging theories that posit curvilinear or procyclical associations between the economy and suicide rates. Although research from Ireland showed no association between socioeconomic factors and suicide after accounting for time trends (68), most studies have suggested that suicide rates tend to decline during times of economic prosperity and increase during periods of recession (29, 33, 37, 40). In a recent review of the population-level mental health effects of economic downturns, Zivin et al. (69) inferred a positive association between economic crises and the onset of psychopathology, including suicide and mood disorders.

Parametric techniques for assessing the relation between economic conditions and suicide rates may not adequately account for time-varying confounding by seasonal, long-term secular (e.g., provision of emergency services that may influence survival conditional on a suicide attempt), or long-term demographic (e.g., changes in age or racial composition) trends. Our work, in which we aimed to improve on extant research by applying GAMs with smoothing functions to handle time-varying confounding, corroborated prior work that showed a negative relation between economic activity and suicide rate in an urban context. On average, rates of suicide in NYC were lower when economic activity was greater. Specifically, there was a difference of 0.12 per 100,000 persons in the average predicted monthly rate of suicide when economic activity was at its peak (ICEI = 115.5) compared with when it was at its nadir (ICEI = 99.8).

The overall pattern between economic activity and suicide rates was driven primarily by whites, men, and older adults, who accounted for both a consistently higher incidence of suicide and a stronger negative association between the ICEI and suicide than did nonwhites, women, and younger adults, respectively. In studies as early as 1951 (70), researchers showed a stronger association between economic conditions and suicide rates in men relative to women, with more recent work from Australia indicating that suicide rates increased with levels of economic adversity among men but had the opposite pattern among women (45). Fewer studies have

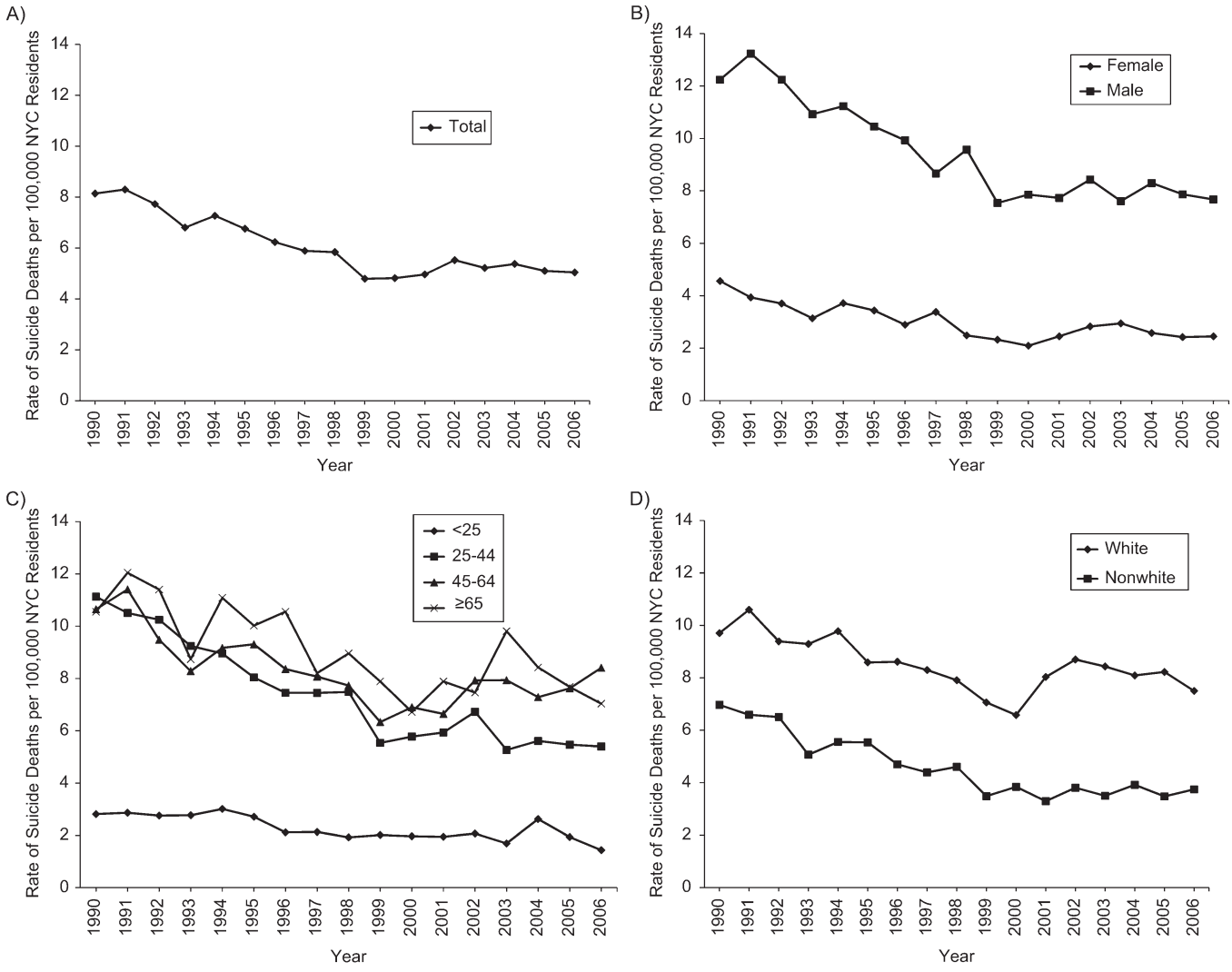

Figure 1. Total (A), sex-stratified (B), age-stratified (C), and race-stratified (D) rates of death by suicide per 100,000 residents in New York City (NYC), 1990–2006.

been conducted to assess whether the relation between economic conditions and suicide is moderated by race/ethnicity or age. In general, our analyses suggested that the association between the ICEI and suicide is more nonlinear for groups, particularly nonwhites and women, that might have fewer socioeconomic resources to buffer them from adverse macroeconomic conditions.

A number of questions remain unanswered and warrant further research. First, it is plausible that individual or contextual (i.e., neighborhood) measures of socioeconomic status moderate the relation between the economic environment and suicide rates (71); however, we are unaware of any work that has investigated these associations. Second, the lag between fluctuations in the economic environment and rates of suicide is undetermined. Some work has suggested that the economic environment has an acute effect on suicide rates. During the Great Depression, for example, suicide rates peaked when gross domestic product growth was at its lowest point (72). However, data from the Asian financial crisis showed inconsistent patterns (35, 37). Our results suggested an acute association between economic activity and suicide, with levels of economic activity associated with rates of suicide within the same month. Third, the mechanisms that link the economic environment to suicide have not been elucidated. Changes in the economic cycle might shift the distribution of factors that predispose persons to suicide and reduce access to salutary resources, such as mental health services and social supports. For example, periods of recession may be associated with increased levels of job insecurity and psychological distress (73, 74). Further work is needed to clarify the pathways that link changes in the economic environment to suicide rates.

Despite numerous reports of suicide induced by losses in stock market wealth, our findings suggested that fluctuations

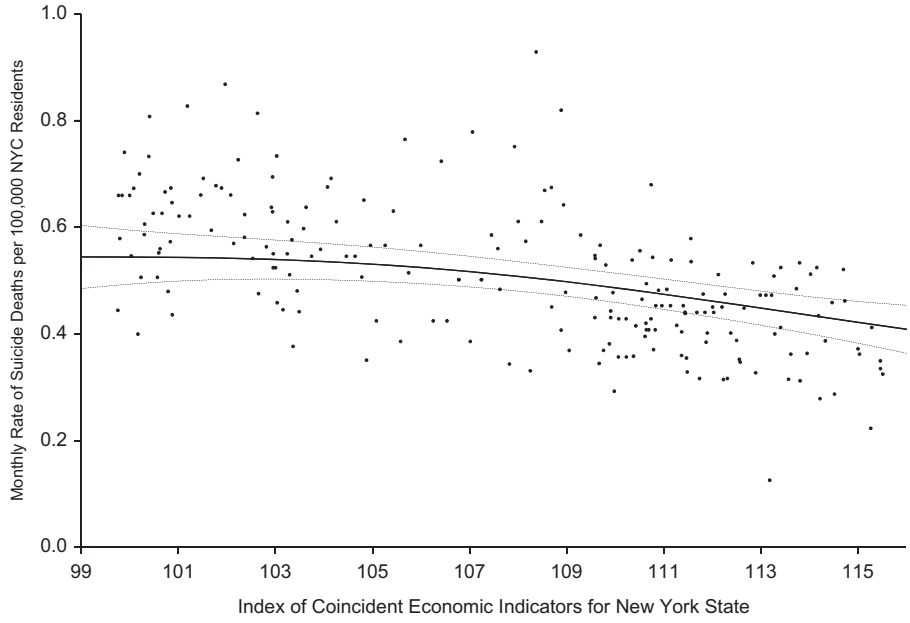

Figure 2. Generalized additive model showing the association between the Index of Coincident Economic Indicators and the predicted monthly rate of violent suicides per 100,000 New York City (NYC) residents after accounting for time trends, 1990–2006. The points indicate the actual monthly rates of suicide per 100,000 residents of New York City. The solid line represents predicted values, and dotted lines indicate 95% confidence intervals.

in the stock market, represented by stock market volatility, do not influence rates of violent suicide at the population level. One potential explanation is that there are not enough people invested in the stock market to detect fluctuations in incidence rates; as Durkheim noted in *Suicide,* ''Many of the individual conditions are not general enough to affect the relation between the total number of voluntary deaths and the population. They may perhaps cause this or that separate individual to kill himself, but not give society as a whole a greater or lesser tendency to suicide'' (19, p. 71). Alternatively, a sufficient causal mechanism for suicide may be multifactorial and losses in wealth, including financial assets, may represent one component of a sufficient cause for suicide. According to a qualitative analysis of 62 cases of suicide involving economic strains, the reason for suicide frequently involved multiple comorbid stressors, such as economic losses and strain in a relationship with a significant other (75). Finally, it is possible that fluctuations in the stock market are decoupled from changes in wealth at the individual or ecologic level through, for example, practices such as short sales of stocks and bonds.

There were a number of limitations to the present analysis. First, although we used smoothing functions of time to account for time-varying confounders that were not explicitly modeled, it is possible that residual confounding due to unmeasured covariates biased our estimates. However, it is unlikely that potential confounders, such as firearm availability (7), varied temporally with levels of economic activity and confounded results between the ICEI and suicide. Second, it is possible that individuals with underlying psychiatric conditions might be more likely to experience job loss or unemployment and commit suicide (71). However, this is unlikely to explain ecologic associations between the economic cycle and suicide. Third, we assessed the relations between 2 measures of the economic environment, the ICEI and a measure of stock market volatility, and suicide. It is possible that these

Table 2. Predicted Monthly Means and Standard Errors of Suicide per 100,000 New York City Residents at Low, Median, and Peak Values of the Index for Coincident Economic Indicators, 1990–2006[a]

Index for Coincident Economic Indicator Value	Total Sample	Race/Ethnicity		Sex		Age, years	
		White	Nonwhite	Male	Female	<45	≥45
99.8 (nadir)	0.54 (0.03)	0.79 (0.05)	0.35 (0.31)	0.92 (0.05)	0.24 (0.02)	0.43 (0.02)	0.78 (0.06)
108.9 (median)	0.50 (0.01)	0.70 (0.02)	0.41 (0.03)	0.81 (0.03)	0.24 (0.01)	0.39 (0.01)	0.74 (0.04)
115.5 (peak)	0.42 (0.02)	0.59 (0.04)	0.28 (0.14)	0.73 (0.04)	0.17 (0.02)	0.36 (0.02)	0.57 (0.05)

[a] Values are from 4 generalized additive models (i.e., total sample and models stratified by race/ethnicity, sex, and age) that account for time trends.

measures do not best capture the economic insecurity or confidence experienced by individuals during economic downturns or upswings, respectively. A sensitivity analysis in which we replaced the ICEI with the unemployment rate showed that the unemployment rate was positively associated with suicide in unadjusted models but not after accounting for seasonal and long-term time trends; these results suggest that prior studies that found a significant positive association between unemployment and suicide may have been confounded, and furthermore, that studies of economic conditions and suicide are sensitive to the measurement of economic conditions used. Fourth, we used the ICEI for New York State, whereas suicide rates were calculated among NYC residents. Although a substantial proportion of NYC residents may have been exposed to the broader economic conditions of the state, our selection of a state-level indicator could have introduced error in the measurement of economic conditions. Fifth, although minimizing the potential for spatial ecologic fallacy, investigations at smaller levels of aggregation, such as urban areas, may have limited external validity. Sixth, we interpolated and extrapolated yearly population estimates stratified by age, sex, and race/ethnicity using estimates from the years 1990 and 2000 and assumed a linear trend.

In summary, macroeconomic forces might influence population mental health. However, additional work is necessary to address several unanswered questions, including which mechanisms link economic conditions to suicide.

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