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ORIGINAL ARTICLE

Changes in trauma admission rates and mechanisms during recession and recovery: evidence from the Detroit metropolitan area

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Abstract

Objectives Although individual socioeconomic status has been linked with risk of traumatic injury, there has been relatively little research into the question of how economic changes may impact trauma admission rates in neighborhoods with different socioeconomic backgrounds.

Methods This study pairs ZIP code-level data on trauma admissions with county-level data on unemployment to assess differences in the type of changes experienced in more and less affluent neighborhoods of the Detroit metropolitan area between 2006 and 2014.

Results Conditional linear growth curve modeling results indicate that trauma admission rates decreased during the "great recession" of 2008–2010 in neighborhoods with the highest unemployment levels, but increased during the same period of time in neighborhoods with lower unemployment. Consequently, citywide disparities in trauma incidence decreased during the recession and widened again as the economy began to improve.

Conclusion Trauma risks and demand for trauma care may shift geographically in relation to broader economic changes. Health care policy and planning should consider these dynamics when anticipating changing demands and needs for efforts at prevention.

Keywords Traumatic injury · Health disparities · Unemployment · Growth curve modeling

Introduction

Although there is strong evidence supporting a link between individual socioeconomic background and the risk of traumatic injury (Cubbin et al. 2000a, b), there has been relatively little research addressing the question of how broader economic changes may affect patterns of trauma at the ecological level. As regional and national economies fluctuate, it is important for hospitals and public health authorities to be able to predict changing demands for specific healthcare resources. The Detroit metropolitan area was one of the regions most strongly affected by the "great recession" of 2008–2010 (Connaughton 2010; Reese et al. 2014), and more broadly has been on the leading edge of a much long-term pattern of post-industrial economic decline and recovery (Kinkead 2016), and contains dramatic examples of socioeconomic and health disparities between neighborhoods (Silverman 2005; Darden et al. 2010). These factors make Detroit an ideal place to examine the interaction between pre-existing disparities between neighborhoods and the impact of economic changes on the incidence of traumatic injury. This study uses data on trauma admissions in the Detroit metropolitan area in the period leading up to, during, and immediately after the great recession to track how changes in trauma rates differ between wealthier and poorer neighborhoods.

Epidemiology of traumatic injury

Approximately 5.8 million people annually die due to traumatic injury worldwide, representing 10% of all deaths, and it is anticipated that this percentage will increase in the coming decades (World Health Organization 2010). Inpatient trauma care is particularly expensive, because it often

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requires treatment from multiple services and specialist physicians (Mathes et al. 2016). It can also incur substantial post-discharge costs for rehabilitative services, and has broader economic implications in terms of lost productivity due to disability (Haeusler et al. 2006).

A variety of factors can place individuals at risk of experiencing traumatic injury. Men have generally been found to have a higher rate of trauma than women (Cothren et al. 2007), possibly because they may tend to engage in more risky behaviors, and use fewer safety precautions when they do (Harris et al. 2006), as well as because they may be more likely to be employed in occupations that involve more physical risk (Islam et al. 2001). As they get older, people become more susceptible to certain types of common injury, including falls, increasing the trauma rate among older adults (Rubenstein 2006). Poverty and unemployment have been found to be important socioeconomic risk factors for trauma (Cubbin et al. 2000a; Berger et al. 2011), placing individuals at higher risk for exposure to environmental hazards such as higher neighborhood rates of violent crime, as well as potentially being related to more risk-taking behavior and less capacity to take precautions against risk.

Aggregating these individual risk factors to the group level, areas with different demographic and socioeconomic backgrounds are prone to having different trauma rates. For example, areas with older populations are likely to have relatively high rates of fall-related trauma, but low rates of firearm-related trauma. In terms of socioeconomic status, it would be expected that poorer neighborhoods and those affected by high unemployment would be likely to have higher trauma rates in comparison to more affluent areas. This expectation has been supported by previous research (Reed et al. 2003; Madan et al. 2007; Berger et al. 2011). Individuals living in these communities face more risks, and have fewer resources to mitigate those risks, in comparison to those living in more affluent communities. In addition to the direct impact on the population of these communities, these disparities also mean that hospitals located near them must cope with greater demand for resources related to treating trauma. Since hospitals serving disadvantaged populations are also likely to be underfunded (Hasnain-Wynia et al. 2007), these demands on the system only serve to further entrench patients in a cycle of poorer health outcomes. This pattern also contributes to higher rates of disability in poorer communities, placing them at a further economic disadvantage (Shraim et al. 2017). This pattern of economic disparities is reflected globally; poor countries suffer the most from high rates of trauma, and poor communities within affluent countries in all world regions have the greatest risk of trauma and the highest economic burden of care (World Health Organization 2010).

Likewise, these patterns of differences would seem to imply that changing socioeconomic conditions would be likely to lead to corresponding changes in patterns of trauma, with improving conditions leading to lower trauma rates and worsening conditions leading to higher ones. Some investigators report that clinicians' perceptions reflect this pattern, with the frequency of trauma cases increasing during periods of rising unemployment (Madan et al. 2007). However, relatively few studies have had the scope to fully assess this hypothesis. From one perspective, conditions in poorer neighborhoods may be more fragile and thus more susceptible to disruption, increasing the impact in the most deprived areas. Conversely, there may be an upward limit on the worst-case trauma rate. If the poorest neighborhoods are already near this maximum, then it may actually be affluent neighborhoods that suffer the most in relative terms in response to economic problems. Increasing economic turmoil may cause wealthier individuals to expose themselves to more of the same risks (e.g., more hazardous occupations, poorly maintained transportation options, and exposure to crime) that poorer individuals are already exposed to in good economic times.

The case of Detroit

Due to factors including the large-scale loss of jobs in the automobile manufacturing industry, the city of Detroit experienced a long-term pattern of economic decline dating at least from the 1960s and reaching its lowest point in July 2013 with the largest municipal bankruptcy in US history, and which has since been followed by tentative moves towards recovery (Kinkead 2016). At the same time, the surrounding suburban counties experienced a population boom (primarily due to out-migration from the city itself) and relative economic prosperity. The region was affected particularly in the recession of 2009–2010, with the city of Detroit experiencing an unemployment rate of more than 28% at its worst (Bureau of Labor Statistics 2017). The Detroit metropolitan area also suffers from some of the most serious and dramatic disparities in both socioeconomic background (Silverman 2005) health outcomes (Darden et al. 2010) between neighborhoods. It is an ideal area on which to focus attention with respect to this study, because of its record of extreme economic changes in a relatively short period of time, and because the area reflects many of the same long-term economic trends underway in much of the US, and in much of the developed world, as old industrial economies change.

Hypotheses

Hypothesis 1 Neighborhood-level rates of trauma admission changed over the period of the great recession.

Hypothesis 2 The rate of change in trauma admission during this time period varied depending on the relative socioeconomic background of the neighborhood.

Hypothesis 3 The pattern of changes observed differs depending on the mechanism of trauma (all trauma, fall-related, firearm-related, and motor vehicle traffic related).

Methods

Individual-level admissions data for this project were obtained from the Healthcare Cost and Utilization Project (HCUP), sponsored by the agency for health research and quality (AHRQ). One element of the HCUP is the compilation of an annual database including medical details of all hospital discharges in each state, known as the state inpatient database (SID). Data for the present analyses come from the Michigan SID for the period of years from 2006 to 2014. Patients residing in the Detroit metropolitan statistical area (MSA) were identified using the US Census Bureau definition as consisting of Wayne, Lapeer, Livingston, Macomb, Oakland, and St. Clair counties. Trauma cases were identified using ICD-9 diagnostic codes present at admission.

Individual data on trauma admissions from the Michigan SID were aggregated at the ZIP code level and matched by year with county-level unemployment data from the Bureau of Labor Statistics. Correspondingly, the unit of analysis in this study is the neighborhood. Annual ZIP code-level population estimates were obtained from Internal Revenue Service data. Dependent variables of interest were the total rate of trauma and mechanism-specific rates of trauma from falls, firearms, and motor vehicle traffic per 10,000 population within ZIP code. County-level unemployment was centered within year to control for changes in the overall unemployment rate (e.g., the mean county-wide unemployment rate was 5.2 in 2006 and 11.9 in 2009). Using the annual unemployment rate also served to control for seasonal variations and other short-term fluctuations in the labor market.

Analysis

Conditional linear growth curve modeling (GCM) was used to assess the impact of unemployment on the pattern of change in neighborhood-level trauma rate over the course of the study period. The GCM technique is used to estimate a polynomial equation representing the average trajectory of all of the particular individual trajectories of change over time in terms of the outcome variable for each unit studied (Duncan et al. 2006). In this case, the neighborhood is the unit of analysis, so the GCM procedure is based on averaging the relationship between time and the within-neighborhood trauma rate across all ZIP codes. Conditional GCM adds a third variable to the equation to produce an estimate of how the mean trajectory of change differs depending upon the value of that variable. In this case, unemployment is the conditional variable, so the model is designed to estimate how neighborhood unemployment levels affect the pattern of change in trauma rate over time. The same procedure was implemented separately for four outcomes: total trauma rate, fall-related trauma rate, firearm-related trauma rate, and motor vehicle traffic-related trauma rate. Models were estimated using PROC MIXED in SAS 9.4.

Preliminary analyses indicated that a cubic model for time provided the best fit with the data. Therefore, time was modeled as a third-order polynomial function by including three effects in the model: linear (year), quadratic (year × year) and cubic (year × year × year). The value for year was centered on its grand mean to accommodate the quadratic and cubic interaction effects. Together, these three effects represent the unconditional growth curve for change in the outcome over time. The conditional growth curve is added to the model by including three corresponding interaction effects for unemployment by each component of the growth curve (i.e., unemployment × linear, unemployment × quadratic, and unemployment × cubic). In isolation, the linear component represents net change between the beginning and end of the time period represented, the quadratic component represents an inflection point in the change of the linear slope, and the cubic component represents a second inflection in the slope. The corresponding conditional effects indicate the presence of differences in each of these components as a function of unemployment. All three components must be interpreted together as an estimate of the curvilinear relationship between time and the outcome variable. Likewise, the conditional unemployment by time effects are interpreted together to provide an estimate of how the curvilinear shape of the trajectory of change differs depending on the neighborhood unemployment level.

Results

Descriptive statistics by year are presented in Table 1. Results for the linear mixed models estimating the conditional GCM analyses are presented in Table 2, and the shape of the trajectories are illustrated in Figs. 1, 2, 3 and 4. All three hypotheses regarding changes in trauma admission rates during the recession were supported by the data. Significant effects for time (year) indicate that trauma rates changed during the time period from 2006 to 2014, in support of Hypothesis 1. Significant interaction effects

Table 1 Descriptive statistics, mean (SD), Detroit, Michigan, USA region (2006–2014)

	2006	2007	2008	2009	2010	2011	2012	2013	2014
Unemployment rate	7.0 (1.1)	7.2 (1.2)	8.2 (1.3)	15.1 (1.8)	14.0 (1.9)	11.4 (1.6)	10.1 (1.6)	9.9 (1.7)	8.3 (1.4)
Trauma rate									
Overall	108.3 (59.5)	110.1 (48.7)	117.6 (54.5)	120.1 (52.1)	115.8 (45.1)	117.7 (43.7)	120.0 (48.4)	118.5 (45.4)	121.1 (46.7)
Falls	32.4 (14.9)	30.8 (14.1)	33.5 (16.3)	35.0 (17.4)	34.5 (16.0)	34.6 (16.2)	33.6 (16.8)	33.1 (16.7)	28.4 (14.9)
Firearms	2.1 (4.6)	1.7 (3.4)	2.0 (4.1)	1.6 (3.6)	1.6 (3.0)	1.8 (3.8)	2.0 (4.5)	2.0 (4.1)	1.4 (2.8)
Motor vehicle traffic	8.3 (6.9)	7.1 (5.6)	6.8 (5.6)	6.6 (4.3)	6.7 (4.4)	6.9 (4.2)	6.4 (5.9)	6.4 (4.8)	5.2 (4.7)

between the relative unemployment rate and the three components of the time effect indicate that, in support of Hypothesis 2, the rate of change differed between neighborhoods as a function of economic conditions. Finally, as the presence of different significant components of growth (as indicated by the linear, quadratic, and cubic coefficients for time) indicate, trauma due to different mechanisms had different patterns of change during this time period, in support of Hypothesis 3.

More economically challenged neighborhoods suffered from worse trauma rates throughout the 2006–2014 period for all forms of trauma. However, in many respects these disparities actually appeared to become smaller as the recession began: trauma rates increased in more affluent neighborhoods, while they tended to decrease in the most impoverished neighborhoods. As the recession ended, it appears that these trends reversed for trauma as a whole, with overall trauma rates beginning to fall in more affluent neighborhoods and rising again in more impoverished ones.

The magnitude of these disparities, and the changes that occurred in them over time, can be gauged from the predicted mean values illustrated in Fig. 1. In 2006, the estimated rate of traumatic for the average low-unemployment neighborhood (i.e., one with an unemployment rate 2.5% lower than the countywide average) was 79 injuries per 10,000 members of the population. The same estimated mean rate for an average high-unemployment neighborhood (i.e., with an unemployment rate 2.5% higher than the average) was 133 injuries per 10,000 population. Thus, the estimated rate of traumatic injury was 69.0% higher in the average neighborhood with high unemployment in comparison to the average neighborhood with low unemployment. By 2012, this gap had narrowed to 15.2%, as the estimated mean rate of traumatic injury in low-unemployment neighborhoods increased to 110 per 10,000 while the estimated rate in high-unemployment areas fell modestly to 127 per 10,000. By the end of the study period in 2014, the disparity had once again widened to 24.4%, with the rate of injury per 10,000 population receding to 107 in low-unemployment areas and rising again to 134 in areas of higher unemployment.

Patterns for the three specific trauma mechanisms examined each indicated declining disparities in trauma admissions coinciding with the start of the recession. The magnitude of these changes differed between mechanisms, as did the comparative effects on high and low unemployment areas. Fall-related trauma increased substantially in low-unemployment neighborhoods, with the estimated mean rate increasing from 22 per 10,000 in 2006 to 30 per 10,000 by 2012, and remained fairly stable in higher unemployment ones, declining marginally from 42 to 40 per 10,000 over the same period. By contrast, motor

Table 2 Mixed model results for change in neighborhood trauma rate as a function of relative annual average county unemployment rate in the Detroit, Michigan, USA region (2006–2014)

	All trauma		Falls		Firearms		Motor vehicle traffic	
	b	*p*	b	*p*	b	*p*	b	*p*
Intercept	118.5	< 0.0001	34.7	< 0.0001	1.8	< 0.0001	6.7	< 0.001
Year								
Linear	0.4	0.3282	0.6	0.0008	0.1	0.0014	0.1	0.1889
Quadratic	− 0.3	< 0.0001	− 0.3	< 0.0001	0.005	0.3964	0.02	0.1541
Cubic	0.09	0.0003	− 0.06	< 0.0001	− 0.01	< 0.0001	− 0.03	< 0.0001
Unemployment	4.1	< 0.0001	2.7	< 0.0001	0.4	< 0.0001	0.8	< 0.0001
x linear	− 0.9	0.0002	− 0.05	0.0003	0.08	0.0018	− 0.04	0.4251
x quadratic	0.2	< 0.0001	0.02	0.4358	0.03	< 0.0001	0.04	< 0.0006
X Cubic	0.01	0.4480	0.01	0.1656	− 0.01	< 0.0001	− 0.003	0.5214

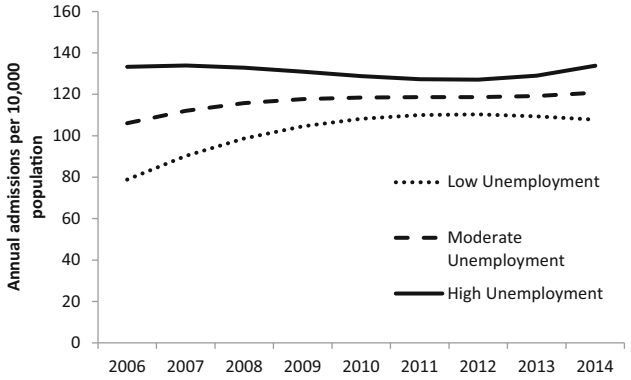

Fig. 1 Change in total neighborhood trauma rate by relative unemployment in the Detroit, Michigan, USA region (2006–2014)

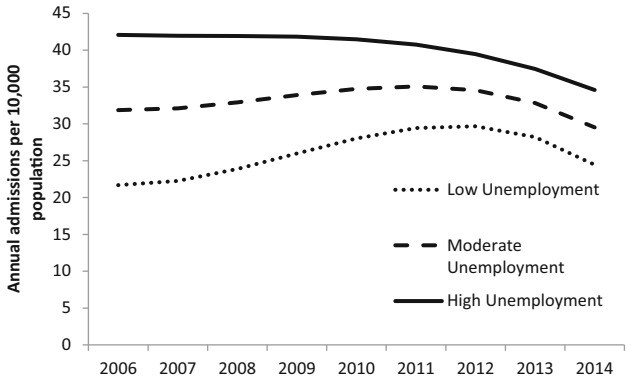

Fig. 2 Change in neighborhood fall-related trauma rate by relative unemployment in the Detroit, Michigan, USA region (2006–2014)

vehicle traffic-related trauma admissions decreased sharply in high unemployment neighborhoods, from 12.9 to 8.8 per 10,000, and remained fairly stable, increasing from 4.1 to 4.7 per 10,000 over the same period, in low unemployment ones. The rate of firearm-related trauma dropped sharply in high unemployment neighborhoods, from a high estimated mean of 5.5 in 2006 to a low of 2.9 in 2010, while also increasing in low unemployment ones, from 0.2 to 1.1 per 10,000 over the same period.

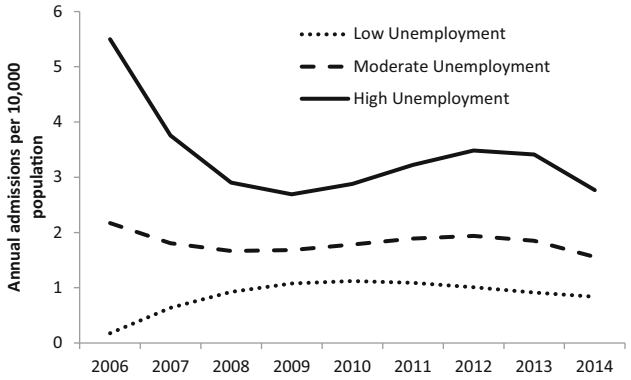

Fig. 3 Change in neighborhood firearm-related trauma rate by relative unemployment in the Detroit, Michigan, USA region (2006–2014)

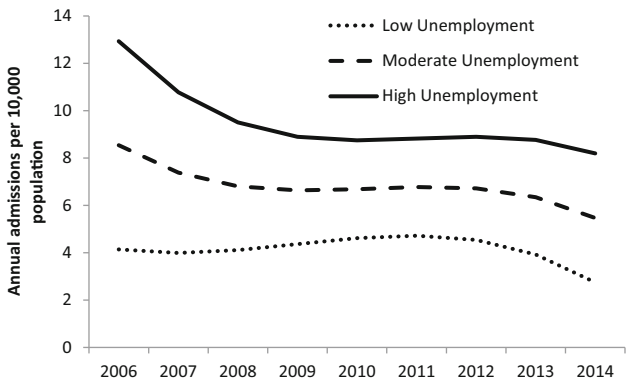

Fig. 4 Change in neighborhood motor vehicle traffic-related trauma rate by relative unemployment in the Detroit, Michigan, USA region (2006–2014)

As the recession ended, overall trauma admissions showed signs of beginning to return to pre-recession levels, particularly in more disadvantaged neighborhoods. Trauma related to both falls and motor vehicle traffic appeared to decline somewhat across the board, Firearm-related trauma admissions increased as the recession ended, most dramatically in the most disadvantaged neighborhoods, before

appearing to decline again after 2012, possibly reflecting long-term national trends towards lower levels of gun violence (Wintemute 2015).

The magnitude of these disparities was greatest for firearm-related trauma, which occurred at a mean estimated rate more than 30 times more often in neighborhoods with high unemployment, compared with low-unemployment areas in 2006. By 2010, this gap had narrowed dramatically, so that this type of trauma was only 157% more common in high versus low unemployment neighborhoods. The gap widened again as the economy improved, rising to a disparity of 273% in 2013 and 231% in 2014. Disparities in trauma due to motor vehicle accidents followed a similar, albeit less extreme, pattern, with high-unemployment areas experiencing a mean estimated trauma rate 212% higher in 2006, narrowing to a gap of only 87% in 2011, and expanding again to 1.98% by 2014. Similarly, the rate of trauma due to falls was 94% higher in high-unemployment areas in 2006, with the gap narrowing to only 33% by 2012, before again widening to 42% by 2014.

Discussion

Health care disparities are a recognized evil in our health care system[4]. Our study sought to quantify one of the elements of this disparity during times of economic stress. Most studies point to increased prevalence of trauma in economically disadvantaged communities. Intuitively, it would be expected that trauma prevalence will increase more rapidly in economically disadvantaged areas as economic conditions falter. Recent studies examining changes in trauma rates during periods of recession found evidence of increases in trauma related to causes including gunshot wounds (Guzman et al. 2017) and abuse-related pediatric head trauma (Huang et al. 2011; Berger et al. 2011) as economic conditions worsened. However, our study of one urban area, albeit an area of significant economic turmoil, showed that as the recession worsened trauma incidence more broadly actually decreased in economically poorer neighborhoods when compared to richer areas.

Economic recession may increase exposure to trauma risks, but these results suggest that this negative impact is felt less in areas that were already disadvantaged before the recession. The current data do not allow us to draw conclusions about the reasons that may lie behind these patterns. We can postulate that during recessions, economic activity decreases disproportionately more in poorer neighborhoods. Decrease in economic activity may affect trauma incidence as diminished economic activity can decrease opportunity for trauma. Residents of poorer neighborhoods are likely to be employed in more hazardous occupations in the industrial and construction sectors, so rising unemployment may reduce exposure to work-related risks. Likewise, lack of work and more limited resources to spend on leisure activities may reduce the amount of travel by motor vehicle undertaken in poorer neighborhoods, reducing risk of trauma from these sources. Violent crime, particularly related to robbery and theft, may also decline because of perceptions that residents of poorer neighborhoods are less likely to have property worth stealing during bad economic times.

Conversely, results of this study indicated that trauma rates rose significantly during the period of the recession in more affluent neighborhoods. Again, the reasons for these apparent changes remain speculative. Possibilities include wealthier individuals being prompted to economize by cutting back on safety precautions that might help prevent traumatic injury, for example, by foregoing home and automobile maintenance. Poorer employment prospects may lead more residents of these neighborhoods to commute longer distances. Violent crime may also increase in these areas as wealthier neighborhoods become more desirable targets and as local governments cut back on budgets for police and public safety.

These results suggest an ironic effect that an improving economy actually exacerbates the disparities between rich and poor communities, at least in terms of some forms of trauma risk. However, the data also suggest that in most cases the rates of trauma admission were relatively slow to return to pre-recession levels as economic conditions improved. Long-term national trends suggest that rates of motor vehicle-related injury have been declining largely due to improvements in automobile safety technology (Kramarow et al. 2015; Cicchino 2015), while rates of firearm-related trauma have declined as a function of declining violent crime rates (Wintemute 2015). Fall-related trauma, meanwhile, is thought to be in a long-term pattern of increase linked with the aging US population (Rubenstein 2006; Kramarow et al. 2015). In the sample examined in this study, these patterns appear to have been disrupted during the recession, highlighting the importance of taking economic changes into account when planning for long-term shifts in demand for trauma-related resources.

The study raises societal questions as to why trauma rates decrease disproportionately during periods of economic recession in poorer neighborhoods. Although a reduction in trauma rates is itself beneficial, the possibility that it may reflect the effects of deepening economic disadvantage (for example, by limiting exposure to occupational and recreational risk factors) complicates this finding. In terms of clinical and policy implications, hospitals may be advised to expect more demand for resources related to trauma treatment in more affluent neighborhoods in times of economic crisis, and rising demand for the same resources in poor neighborhoods as conditions improve.

Makers of health policy may also benefit by considering the need to adapt policies and approaches based on economic changes. For example, public health campaigns focused on trauma prevention may be advised to explore changing the areas and populations that they target as needs may change in response to economic conditions.

Future research could help to clarify and extend these findings. For example, the data used in this study did not include information regarding injury severity; future research could examine economic effects on trends in major trauma in comparison with trauma as a whole. The addition of micro-level data could also help to clarify whether these changes are reflected in individual-level processes (i.e., does individual trauma risk increase after becoming unemployed).

Limitations of the study include a lack of ZIP code level data on unemployment, necessitating the use of county-level statistics for this measure. Additionally, because the SID does not maintain records for traumatic injury events resulting in death prior to hospital admission, it is not possible to determine what if any proportion of changes in trauma rates observed were due to changes over time in pre-hospitalization mortality. Finally, the economic situation of the Detroit metropolitan area may have some idiosyncrasies which may suggest that caution is needed in generalizing these findings to other regions. The experience of the Detroit area is representative of a long-term pattern of post-industrial economic change—including loss of jobs in the manufacturing sector, decline in working class wages, and depopulation of core urban neighborhoods—common to many "rust belt" areas of both North America and Europe (Audirac 2017). These are the areas to which the results of this study are most likely to be readily extended. Since these economically disadvantaged regions are likely to face disproportionate health challenges, these insights may prove to be especially valuable there. Future research should explore the extent to which recession has the same implications in regions with more robust underlying economies.

Economic change affects every community, and in an era of increasing uncertainty regarding how health systems will be funded, it is more important than ever for policy makers and clinical care providers alike to be able to anticipate what resources will be needed most when these changes occur. Evidence from the Detroit area during the recession of 2008–2010 suggests that the cycle of economic downturn and recovery may be related to shifting patterns of trauma admission. This study represents a first step towards quantifying these changes, which we hope will spur further research regarding the causes of these changes and how they might one day be more accurately predicted and addressed.

Compliance with ethical standards

Conflict of interest None-all authors declare that they have no conflicts of interest.

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