Suicide, overdose and worker exit in a cohort of Michigan autoworkers

Ellen A Eisen,[1] Kevin T Chen [ORCID],[1] Holly Elser [ORCID],[2] Sally Picciotto,[1] Corinne A Riddell,[3] Mary A Combs,[3] Suzanne M Dufault,[3] Sidra Goldman-Mellor [ORCID],[4] Joshua Cohen[5]

ABSTRACT

Background In recent decades, suicide and fatal overdose rates have increased in the US, particularly for working-age adults with no college education. The coincident decline in manufacturing has limited stable employment options for this population. Erosion of the Michigan automobile industry provides a striking case study.

Methods We used individual-level data from a retrospective cohort study of 26 804 autoworkers in the United Autoworkers-General Motors cohort, using employment records from 1970 to 1994 and mortality follow-up from 1970 to 2015. We estimated HRs for suicide or fatal overdose in relation to leaving work, measured as active or inactive employment status and age at worker exit.

Results There were 257 deaths due to either suicide (n=202) or overdose (n=55); all but 21 events occurred after leaving work. The hazard rate for suicide was 16.1 times higher for inactive versus active workers (95% CI 9.8 to 26.5). HRs for suicide were elevated for all younger age groups relative to those leaving work after age 55. Those 30–39 years old at exit had the highest HR for suicide, 1.9 (95% CI 1.2 to 3.0). When overdose was included, the rate increased by twofold for both 19- to 29-year-olds and 30- to 39-year-olds at exit. Risks remained elevated when follow-up was restricted to 5 years after exit.

Conclusions Autoworkers who left work had a higher risk of suicide or overdose than active employees. Those who left before retirement age had higher rates than those who left after, suggesting that leaving work early may increase the risk.

Over the past 20 years, mortality rates for drug overdose and suicide have increased in USA across all ages, but most dramatically for working-aged adults.[1][2] Case and Deaton were the first to note rising midlife mortality rates among Caucasian, non-Hispanic Americans aged from 35 to 54 with a high school education or less.[3] They identified drug overdose, suicide and alcohol-related liver disease mortality as the causes of the increase and attributed these 'deaths of despair' to reduced economic opportunity among less educated adults.[4]

Increases in these 'deaths of despair' have since been identified across multiple race and ethnic groups and geographic contexts.[5][6] Rising mortality rates have been reported for US African Americans, Hispanics, Asians and Pacific Islanders, 25–64 years of age, with drug overdoses the leading cause of the recent increases in all these subpopulations.[5][6] Reversing decades of steady decline in all-cause mortality for African Americans and Caucasians,[3] these disturbing shifts are particularly pronounced for midlife individuals without a bachelor's degree.[7] Suicide rates have also increased by 33% since 2000, with the steepest increase for Caucasian men.[8] Though the rise has been less dramatic for suicide than for overdose, it emerged in 2016 as the fourth leading cause of death among adults, aged 35–54.[9] Rural counties had consistently higher suicide rates than metropolitan counties.[10]

Coincident with the increases in midlife mortality rates, the long-term decline in US manufacturing has limited good employment options for many less educated adults. In the 1970s, 36% of all employed US men worked in manufacturing, and in 2018, only 15% did.[11] The most dramatic decreases have occurred since 2000, with a loss of over 5 million jobs.[12] As these well-paying jobs with standard employer–employee relationships and job security have declined, precarious work has been on the rise.[13] Prior to the Great Recession, China's entry into the World Trade Organization in 2001 accelerated its export surge in manufacturing and contributed to US contraction.[14] Impacts of the China Shock are most visible in the local labour markets with a concentration of industries exposed to foreign competition where workers who lose jobs may end up out of the job market entirely.[15]

The US automobile industry offers a striking case study of an impacted industry in decline. From the 1950s until the China Shock of the early 2000s, the 'Big Three' Detroit companies Ford, Chrysler and General Motors (GM) dominated the automobile market. By the late 1960s, foreign automakers began to capture a share of the domestic market. The oil embargo in 1979 further fuelled the rise of imported smaller cars. Detroit automakers responded by shifting to light trucks, minivans, sports utility vehicles and pick-up trucks. Between 1980 and 1996, stronger vehicle safety regulations, increasing oil prices and the emergence of hybridised vehicles further challenged the domestic industry. By 2008, Toyota had become the largest producer worldwide, a title GM had held for 77 years.[16] After the US financial crisis in 2008, the US government bailed out the automobile industry at a cost of $80 billion and restructured GM and Chrysler after they entered bankruptcy in 2009.

This study focuses on the implications of the erosion of the US automobile industry for the mental health and safety of Michigan autoworkers who faced potential job loss. Involuntary worker exit has been found to have substantial effects on depressive symptoms, even after

adjusting for baseline health.[17] Taking advantage of individual-level data from an existing study of a United Autoworkers-General Motors (UAW-GM) cohort, we examine associations between worker exit and risk of suicide and fatal overdose. The cohort includes workers at three GM manufacturing facilities in Michigan—one located in an urban centre, one in a more rural area and one in a small city. We focus on the period since the late 1970s that captures acceleration in the decline of the industry. By the end of follow-up, all three study plants had closed.

METHODS

The UAW-GM cohort mortality study was originally designed to assess the health effects of occupational exposures. Details regarding the study have been described in previous publications.[18 19] Here, we describe the more recently employed subset of the cohort included in this analysis.

Study population

The UAW-GM cohort includes all hourly workers identified through company records at three automobile manufacturing plants in Michigan who were hired between January 1, 1938 and December 31, 1982 and worked for at least 3 years. The study population for this analysis includes the more recent subgroup employed in 1970 or later. Plant 1, located in the urban centre of Detroit, employed almost all the African Americans in the cohort. Plant 2 was located 50 miles west in a small town best known as the site of the Willow Run manufacturing complex during World War II.[20] Plant 3 was further upstate in a once-thriving lumber and manufacturing centre that suffered high unemployment and population loss in the late 1900s. Mortality follow-up starts in 1970 or 3 years after date of hire, whichever comes later, and ends in 2015. Less than 0.6% of the subjects were lost to follow-up.

Exposure

The exposure is worker exit, defined as employment termination at the three plants, and measured in two ways. First, we used time-varying employment status (active or inactive) as an indicator of leaving work. The binary variable equals 0 until the year of termination and 1 thereafter.

Second, we defined exposure as the age at worker exit in order to distinguish retirement from early worker exit. During the follow-up period, unionised jobs at GM offered generous benefits and wages. Retirement benefits depended on a combination of age and tenure and were specified in contract negotiations between GM and the UAW. In 1950, a worker could retire with full benefits after 10 years of employment at age 65. In 1964, the age of eligibility for early retirement with partial benefits decreased from 62 to 55.[21]

All of this informed our decision to categorise age at worker exit, with the reference group defined as leaving work at age 55 or older, when the decision to retire was likely to be voluntary. We assume that workers who left GM earlier, when they were younger than 55 and ineligible for benefits, were less likely to have left voluntarily.[22]

Outcome

Data on vital status and cause of death were obtained through the Social Security Administration, the National Death Index, company records, death certificates and state mortality files.[23] We used diagnostic codes for suicide from the International Classification of Diseases (ICD) 9th and 10th revisions. In the present study, the ICD codes for suicide are E950–E959 (ICD-9) and U03, X60–X84 and Y87 (ICD-10). Those for unintentional overdose are E850–E858 and E980 (ICD-9) and X40–X44 and Y10–Y14 (ICD-10).

Covariates

Individual characteristics, including year of birth, sex (men or women), race (African American and Caucasian or unknown) and work-site (Plants 1, 2 or 3) were obtained from company records. Prior to 1970, race was not systematically recorded on GM employment records at hire. Subjects with unknown race (8.2%) were assumed to be Caucasian in this analysis based on the observed racial composition by plant over calendar time.[18] The analyses were restricted to men because the outcome was too infrequent among women workers (10 suicides and 3 fatal overdoses).

Analytic method

A directed acyclic graph illustrates the anticipated relationships between the exposure, outcome and hypothesised confounding variables (figure 1). Race, plant and calendar year
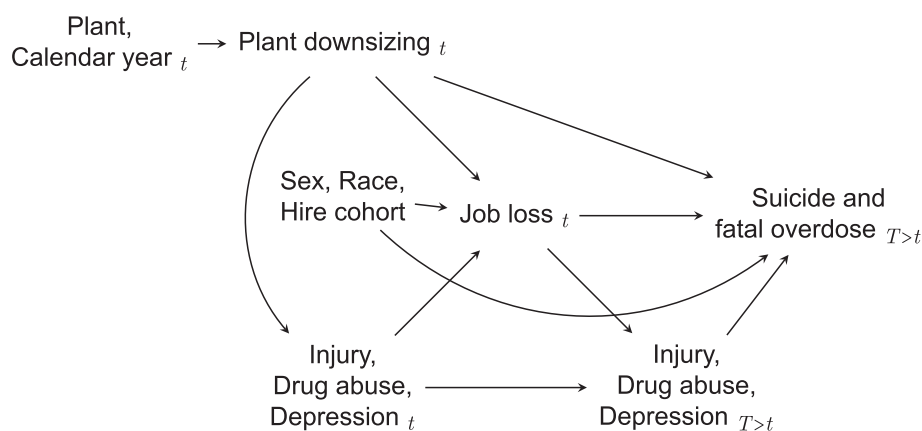

Figure 1 Directed acyclic graph representing our working assumptions about the causal relationships between exposure, outcomes and a simplified set of confounders.

were included in all models to adjust for confounding. Depression, injury and drug abuse, depicted as time-varying confounders affected by prior exposure, were not measured, limiting interpretation of our results.

We contrasted annual rates for suicide with rates for suicide and fatal overdose combined to capture the potential impact of the opioid epidemic in the early 2000s as well as to reduce outcome misclassification. Suicides using opioids and other drugs are substantially under-reported by medical examiners and coroners.[24]

First, adjusted HRs for suicide and overdose were estimated in relation to employment status in a Cox proportional hazards model based on the full cohort. Although mortality follow-up extends to 2015, employment records end on December 31, 1994, and we censor subjects still employed at that time. The time metric for these Cox models was age, and we adjusted for year of hire, and a time-dependent penalised spline function of calendar year of follow-up as confounders.

Second, decade of age at worker exit was the exposure of interest, contrasting workers retiring at retirement age (≥55) versus workers exiting before retirement age. The time metric in these models was years since worker exit; mortality follow-up starts at the date of exit. Individuals still employed when work records end on December 31, 1994 were necessarily excluded from these models because date of exit (and thus start of follow-up) was unknown.

Sensitivity analyses

To account for the possibility that the recorded work termination dates might be artificially back-dated when an employee dies suddenly, we reclassified cases that occurred within a week of leaving work as having occurred while still employed in the first model. To limit the analysis to the most proximal outcomes (those hypothesised to be most likely related to job exit), we restricted follow-up in the second model to 5 years after leaving work.

The study was approved by the Office for the Protection of Human Subjects at the University of California, Berkeley. Analyses were performed in R version 3.6.1. Cox proportional hazards models were estimated using the 'survival' package.[25 26]

RESULTS

Table 1 presents summary statistics for the study population of all male workers employed in or after 1970 and for the subset with complete work records who had left work by December 31, 1994 when employment records were truncated. In the entire cohort of 26 804 men, there were 257 deaths due to suicide (n=202) or overdose (n=55). Plant 2 accounted for 38% of the workers, 46% of the suicides and 62% of the overdose fatalities. In the subset with complete work records, 43.7% left work at age 55 or older. Of those, almost all (97.8%) had worked more than 10 years and were thus eligible for at least a partial pension. Histograms for the age at death by suicide or overdose (online supplementary figure 1) are presented in the online supplementary data.

Figure 2 presents trends for suicide rates from 1970 to 2015 (figure 2A) and for suicide combined with fatal overdose for the entire cohort (figure 2B). The suicide rate increased from 1970 to 1995 and then dropped slightly and plateaued during the 2000s at just over 20 per 100 000. When suicide was combined with fatal overdose, the rates continued to increase throughout the

Table 1 Summary of the UAW-GM cohort restricted to men employed in or after 1970

	Full cohort		Subset with complete work records†	
N (person-years)	26 804	(931 435)	17 553	(565 712)
Race, n (%)				
Caucasian	19 348	(72%)	11 523	(66%)
African American	5 250	(20%)	3 844	(22%)
Unknown	2 206	(8%)	2 186	(12%)
Plant*, n (%)				
Plant 1	6 908	(26%)	6 341	(36%)
Plant 2	10 293	(38%)	6 047	(34%)
Plant 3	9 603	(36%)	5 165	(29%)
Complete work records	17 553	(65%)	17 553	(100%)
Year of hire	1967	(1956, 1975)	1963	(1952, 1969)
Age at hire	24	(20, 31)	26	(21, 34)
Year of birth	1942	(1927, 1950)	1933	(1922, 1946)
Year of worker exit	1991	(1981, 1995)	1984	(1977, 1991)
Age at worker exit	49	(40, 58)	53	(38, 61)
Age at death among deceased	69	(60, 79)	71	(61, 80)
Year of death among deceased	1999	(1989, 2008)	1997	(1988, 2006)
Suicide cases	202		171	
Fatal overdose cases	55		32	

*Some subjects worked at several sites; plant indicates the site of longest work record time.
†Left work by December 31, 1994 when employment records were truncated.
Statistics shown are median (first quartile, third quartile), unless otherwise indicated. UAW-GE, United Autoworkers-General Motors.

time period, reaching 35 per 100 000 in 2015. Some of the workers still employed in 1994 continued to work into the 2000s when the plants were downsizing prior to closing down; Plant 1 closed in 2012, Plant 2 in 2010 and Plant 3 in 2014.

Among the 171 suicides with complete work records, all but 21 occurred after worker exit. The adjusted HR was dramatically elevated for those who had left work (table 2). There was a spike in suicides in the year just after exit, and half of the cases among those no longer at work occurred within 5 years (online supplementary figure 2). When cases that occurred within a week of leaving work were reclassified as having occurred while still employed, the HR decreased from 16.1 to 11.3 (table 2).

Table 3 presents results from the second model that contrasted individuals who left work at retirement versus earlier ages. HRs were elevated by 50–90% for groups who exited before age 40. Those who were 30–39 at worker exit had the highest risk of suicide (HR=1.9, 95% CI 1.2 to 3.0). When overdose was included in the outcome, the HR for that group increased to 2.4, and the HR for the youngest group increased from 1.6 (0.9–2.6) to 2.2 (1.3–3.4). The association between younger age and the combined outcome persisted when follow-up was restricted to the 5 years after worker exit: 2.8 (95% CI 1.6 to 5.1) and 2.4 (95% CI 1.2 to 4.9) for those who left work in their 30s and 20s, respectively (online supplementary table 1).

When a penalised spline function of age at worker exit was substituted for the categorical variable in the Cox models, the HRs for both suicide and the combined outcome were highest for those who left work in their mid-30s (online supplementary figure 3). The maximum HR was almost twofold for suicide and 2.5-fold for overdose combined with suicide, relative to those who left work after age 55. The HRs decline as age at worker exit increases from mid-30s to 55 but remain slightly elevated relative to the risk at retirement age.
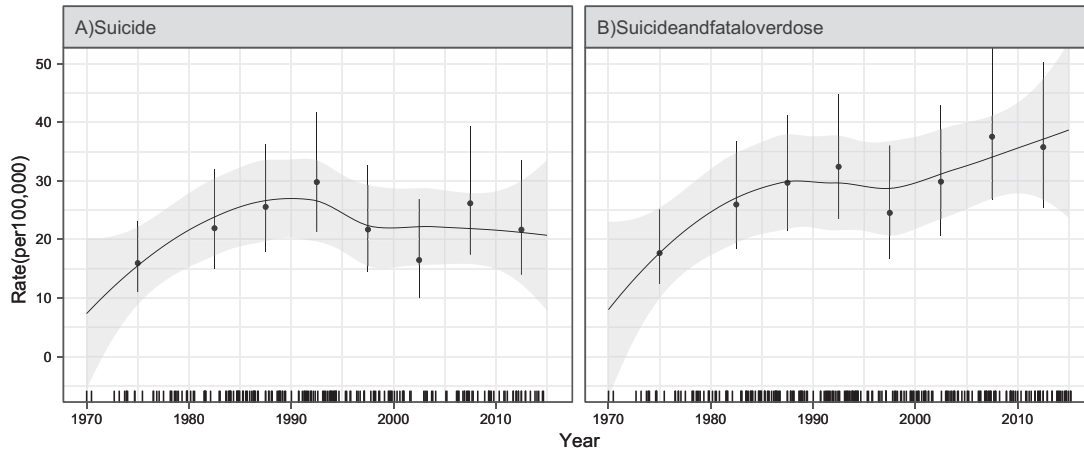
Figure 2 Crude rate (per 100 000 person-years) of suicide and the combined outcome of suicide and fatal overdose by calendar year in the full United Autoworkers-General Motors cohort.

Among the 9251 men still at work on December 31, 1994, there were 54 additional cases, 31 suicides and 23 fatal overdoses. Although we do not know exactly when those cases with incomplete work records left work, almost all the overdoses occurred in Plant 2 during the years leading up to the closing of that plant in 2010.

DISCUSSION

This study used data from an existing cohort study initially designed to assess the health effects of occupational exposures to examine the implications of leaving work for risk of death by suicide and overdose. Our results suggest that leaving work prior to retirement age was associated with increased risk even when follow-up was restricted to 5 years after worker exit. Few deaths by suicide or overdose occurred while workers were still employed, and most occurred among those who left work before age 55. These results are consistent with sociological studies of the health consequences of worker exit.[17 27 28] Although we have no data on subsequent employment, the literature suggests that rehire may mitigate the adverse impacts, but does not eliminate the distress.[27]

These findings are also consistent with recent studies linking conditions of employment with mental health, suicide and overdose mortality. We reported effects of layoffs on mental health-care usage and injury risk among workers at 30 US plants using a difference-in-differences approach.[29] In that study, the increase in the probability of mental health-related prescriptions appeared attributable primarily to opioid use. In an ecologic study leveraging variation in state economic policies over time, a quasi-experimental design was used to examine the impact of minimum wage and earned income tax credit policies on deaths of despair. Causal models suggest that increasing both by 10% would have

prevented 1230 suicides annually, but have no impact on drug overdoses.[30] Another study found that higher state-wide union density was associated with lower mortality rates for suicide and overdose.[31] In a study directly relevant to this one, a difference-in-differences approach estimated an association between county-level automobile assembly closures, from 1999 to 2016, and opioid mortality.[32]

Of the three study plants, Plant 2 had the highest incidence rate of suicide in this study. This plant was located at the site of Willow Run, a factory in southeastern Michigan renowned for the mass production of fighter planes during World War II.[20] Constructed by Ford Motor Company in 1941 to produce the B-24 Liberator heavy bomber, the plant was the largest in the world at the time, employing more than 100 000 workers. Willow Run was sold to GM after a fire in 1953. By 1970, it employed 10 000 workers making automatic transmissions. Plant 2 closed in 2010 as part of GM's bankruptcy proceedings. In 1970, the population of the surrounding township was 30 000; today it is 20 000. This scenario dramatises the challenges smaller towns face in coping with the decline in manufacturing.

Limitations

The analysis presented here is constrained by the study data, in that employment records end in 1994 although the plants continued to operate into the 2000s and follow-up continued until 2015. Interpretation of our results is further constrained by lack of information on injury, drug abuse, or diagnosis or treatment for depression. As illustrated in the causal diagram

Table 2 Adjusted HR estimates for suicide by employment status in the full UAW-GM cohort, using recorded worker exit date and the reclassified worker exit date

	Recorded worker exit date			Reclassified worker exit date*		
Job exit status	n	HR	95% CI	n	HR	95% CI
At work	21	1.0	–	27	1.0	–
Not at work	150	16.1	9.8, 26.5	144	11.3	7.1, 17.8

*Cases that occurred within a week after the recorded worker exit date were assumed to have occurred while still employed.
UAW-GM, United Autoworkers-General Motors.
Estimates were adjusted for race, plant, year of hire and time-varying calendar year. Risk sets were indexed by age. Those still at work on December 31, 1994 were censored on that date.

Table 3 Adjusted HR estimates for suicide and the combined outcome of suicide and fatal overdose by age at worker exit in the subset of the UAW-GM cohort with complete work records

	Suicide			Suicide and fatal overdose		
Age at worker exit	n	HR	95% CI	n	HR	95% CI
55 or older	39	1.0	–	42	1.0	–
40–54	44	1.5	1.0, 2.3	47	1.5	1.0, 2.3
30– 39	39	1.9	1.2, 3.0	51	2.4	1.6, 3.6
19– 29	28	1.6	0.9, 2.6	40	2.2	1.3, 3.4

UAW-GM, United Autoworkers-General Motors.
Estimates were adjusted for race, plant, and calendar year of worker exit. Risk sets were indexed by time since worker exit.

(figure 1), it is plausible that these factors contribute to the risk of both worker exit and suicide and are therefore time-varying confounders. Without information on mental health status over time, we cannot adjust for confounding or isolate the direct effect of worker exit from a mediating pathway through ongoing depression.

Suicide rates in the US are higher for men than for women and have increased substantially for the middle-aged of both sexes since 1999. Suicide risk among 45-year-old to 64-year-old men was higher than for those aged from 25 to 44, with rates of 29.7 and 24.3 per 100 000, respectively, in 2014.[8] To the extent that suicide risk increases for older age groups, there will be less potential for confounding by age when follow-up is restricted to 5 years after exit. The bias, however, would be toward the null, since retirees are the reference in this study.

Although suicide rates are slightly higher for older ages, competing risks from other causes of death, for example, cardiovascular disease and cancer, are far more likely for workers who are oldest at the time of leaving work. The direction of this bias depends on the relative risk of suicide among the observed and unobserved older workers; arguments could be made to support either direction.

Our findings are most precise for suicide. Mortality follow-up ends in 2015, and we observed a rise in the number of overdose fatalities in the last 10–15 years of follow-up, from 2000 to 2015. Together, the trends suggest that since the 1990s, suicide rates have fallen in this cohort as the rate of drug overdose has increased, consistent with the steeply rising rate of opioid mortality in the US since 1999. In total, however, there were too few overdose cases to examine separately.

CONCLUSIONS

Michigan autoworkers who left work after 1970 had a higher risk of death from suicide or overdose than those who remained actively employed. Those who left prior to retirement age had higher rates than those who left after, suggesting that leaving work early may increase the risk.

What is already known on this subject

► US suicide and overdose mortality rates are rising for working-age adults with no college education.
► Manufacturing has been declining in the US for decades, as precarious work has been increasing.
► Economic contraction and job loss have been linked to suicide, depression and substance abuse.

What this study adds

► Individual-level findings from a large established cohort study of autoworkers followed from 1970 to 2015, covering the recent period of decline in the US automobile industry.
► The cohort included all workers who ever worked at three automobile manufacturing facilities in Michigan, all of which closed by the end of the study period.
► We found that suicide was associated with employment status; the hazard rate was 16 times higher among inactive workers who had terminated employment.
► When compared to rate among retirees, the rate of suicide combined with overdose was elevated for workers who left work younger, when leaving was less likely to be voluntary.

Author affiliations
¹School of Public Health, Division of Environmental Health Sciences, University of California Berkeley, Berkeley, California, USA
²School of Medicine, Stanford University, Stanford, California, USA
³School of Public Health, Division of Epidemiology and Biostatistics, University of California Berkeley, Berkeley, California, USA
⁴School of Social Sciences, Humanities, and Arts, Department of Public Health, University of California Merced, Merced, California, USA
⁵Apple University, Apple Inc, Cupertino, California, USA

Twitter ElserHolly.

ORCID iDs
Kevin T Chen http://orcid.org/0000-0003-3971-4628
Holly Elser http://orcid.org/0000-0003-1781-904X
Sidra Goldman-Mellor http://orcid.org/0000-0001-7726-0845

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