SSM - Population Health 12 (2020) 100699

Contents lists available at ScienceDirect

SSM - Population Health

journal homepage: http://www.elsevier.com/locate/ssmph

Socioeconomic disparities in U.S. mortality: The role of smoking and alcohol/drug abuse

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ARTICLE INFO

Keywords:
Socioeconomic status
Mortality
Cause-specific mortality
Smoking
Alcohol abuse
Drug abuse

ABSTRACT

Prior studies have identified smoking as a key driver of socioeconomic disparities in U.S. mortality, but the growing drug epidemic leads us to question whether drug abuse is exacerbating those disparities, particularly for mortality from external causes. We use data from a national survey of midlife Americans to evaluate socioeconomic disparities in all-cause and cause-specific mortality over an 18-year period (1995–2013). Then, we use marginal structural modeling to quantify the indirect effects of smoking and alcohol/drug abuse in mediating those disparities. Our results demonstrate that alcohol/drug abuse makes little contribution to socioeconomic disparities in all-cause mortality, probably because the prevalence of substance abuse is low and socioeconomic differences in abuse are small, especially at older ages when most Americans die. Smoking prevalence is much higher than drug/alcohol abuse and socioeconomic differentials in smoking are large and have widened among younger cohorts. Not surprisingly, smoking accounts for the majority (62%) of the socioeconomic disparity in mortality from smoking-related diseases, but smoking also makes a substantial contribution to cardiovascular (38%) and all-cause mortality (34%). Based on the observed cohort patterns of smoking, we predict that smoking will further widen SES disparities in all-cause mortality until at least 2045 for men and even later for women. Although we cannot yet determine the mortality consequences of recent widening of the socioeconomic disparities in drug abuse, social inequalities in mortality are likely to grow even wider over the coming decades as the legacy of smoking and the recent drug epidemic take their toll.

1. Introduction

Americans experience huge socioeconomic disparities in mortality, regardless of whether socioeconomic status (SES) is measured by education (e.g., Ho & Fenelon, 2015; Sasson, 2016a), income (e.g., Chetty et al., 2016), wealth (Shaw et al., 2014), occupation (Stringhini et al., 2010), or a composite measure of SES (Nandi et al., 2014). For example, Sasson (2016a) reported a nearly 12-year difference in life expectancy at age 25 in 2010 between non-Latinx White men with fewer than 12 years of education and their counterparts with at least 16 years of education. Over the period 2001–14, Chetty et al. (2016) found a 14.6-year gap in life expectancy at age 40 between the richest 1% and the poorest 1% of men; the corresponding disparity was 10.1 years for women. Prior studies have identified smoking as a key driver of socioeconomic disparities in U.S. mortality (e.g., Denney et al., 2010; Ho & Fenelon, 2015; Koch et al., 2015), but the growing drug epidemic leads us to question whether substance abuse is exacerbating socioeconomic disparities.

Most studies of SES disparities in mortality have used a proxy measure that captures only one dimension of SES and thus, cannot represent the total effect of what is, by definition, a multidimensional construct. Many studies have relied solely on education, which is prone to the problem of lagged selection bias (i.e., differences between noncomparable subgroups are misinterpreted as time trends in a broader group; Dowd & Hamoudi, 2014); as education levels have increased over time, high school dropouts have become a rare and select segment of the US population. Between 1991 and 2005, Hendi (2015) found that shifts in the distribution of education explained 87% of the widening in the

Abbreviations: BMI, Body Mass Index; MSM, Marginal Structural Model; MIDUS, Midlife in the United States; SAQ, Self-Administered Questionnaire; SES, Socioeconomic Status.

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https://doi.org/10.1016/j.ssmph.2020.100699
Received 11 August 2020; Received in revised form 22 October 2020; Accepted 18 November 2020
Available online 25 November 2020

educational differential in life expectancy between age 25 and 65 among non-Latinx White women. The effect of education may reflect, at least in part, cohort differences in educational attainment. Income and wealth are likely to be particularly salient in midlife and later life. Some studies included multiple SES indicators (e.g., education, income, wealth) simultaneously (e.g., Denney et al., 2010), but as Nandi et al. (2014) pointed out, this practice does not provide an estimate of the full impact of SES because each indicator represents an "independent" effect while holding the other SES indicators constant. Other researchers entered various SES indicators one at a time (e.g., Groeniger et al., 2017), but again that strategy does not capture the overall effect of SES. Bravemen et al. (2005) convincingly argues that education is not a good substitute for income (or vice versa), nor is income an adequate proxy for wealth. A composite measure of SES is more likely to capture the complexity of inter-related factors that determine one's access to collectively desired resources (Oakes, 2020; Oakes & Rossi, 2003).

Prior studies, all of which are based on education rather than a multidimensional measure of SES, document that the SES gap varies by cause of death. In absolute terms, mortality from smoking-related diseases, external causes, and cardiovascular diseases exhibited the widest educational disparities among non-Latinx Whites and Blacks of both sexes, whereas educational differentials in mortality from diabetes, cerebrovascular disease, non-smoking related cancers, and non-smoking-related respiratory diseases were very small (Sasson, 2016b). Sasson (2016b) concluded that those first three groups of causes explained 60–80% of the educational gap in adult life expectancy for non-Latinx Whites during 1990–2010. Masters, Hummer, & Powers, 2012 also found large educational disparities in heart disease and lung cancer mortality, but smaller disparities in cancers they defined as "unpreventable" (e.g., cancers with a preventability rating less than 4.0; (Phelan, Link, Diez-Roux, Kawachi, & Levin, 2004), Appendix A). Case and Deaton (2017, 2015) suggested that educational disparities in mortality are particularly large for the so-called "deaths of despair" (i.e., drug-related, alcohol-related, and suicides).

Many researchers have investigated the role of health behaviors in the link between SES and mortality in the US (e.g., Nandi et al., 2014; Shaw et al., 2014) and other countries (e.g., Groeniger et al., 2017; Stringhini et al., 2017). Smoking was often found to be the largest contributor to the SES gap in mortality (e.g., Koch et al., 2015), although Nandi et al. (2014) found that, compared with current smoking, alcohol consumption explained slightly more of the SES disparity in mortality among older Americans. Ho and Fenelon (2015) demonstrated that the share of the educational disparity in life expectancy at age 50 attributable to smoking declined from 54% in 1986–94 to 34% in 2003–06 among non-Latinx White men, whereas it increased from 18% to 24% among corresponding women over the same period. Denney et al. (2010) showed that the role of smoking varies by sex and age, which they attributed to differences by sex, cohort, and SES in the diffusion of smoking. For example, men took up smoking earlier than women (Lopez, 1995). Individuals with high SES were among the first to adopt smoking (Ferrence, 1989), but were also among the first to forgo or stop smoking as knowledge emerged about the dangers.

Few studies have quantified the extent to which health behaviors mediate SES disparities in cause-specific mortality. One study in England (Stringhini et al., 2010) revealed that smoking accounted for the largest share (35%) of the occupational disparity in all-cause mortality, but alcohol consumption (18%) made a slightly larger contribution than smoking (12%) for cardiovascular mortality. Another study in Finland (Laaksonen et al., 2008) found that smoking made a large contribution to educational disparities in all-cause mortality (28% for men, 22% for women). Smoking also accounted for the largest share of the educational disparity in cardiovascular mortality among men (30%), but played a lesser role among women (6%) (Laaksonen et al., 2008). Neither of these studies examined external causes or smoking-related diseases.

SES is inversely associated with drug abuse (Glei et al., 2020; Glei and Weinstein, 2019), which may amplify SES disparities in mortality. Yet, none of the studies mentioned above considered drug abuse, although many of them included alcohol consumption. Ho (2017) estimated that drug overdose mortality accounted for up to 5% of the educational disparities in life expectancy at age 25, but that may underestimate the impact of drug abuse, which can affect mortality from many causes other than overdose. Also, that study was unable to account for smoking and alcohol abuse as competing mediators.

In this paper, we use data from a national survey of midlife Americans to evaluate socioeconomic disparities in all-cause and cause-specific mortality over an 18-year period (1995–2013). Then we investigate the role of smoking and alcohol/drug abuse in mediating the SES disparities in mortality. Among the key strengths of this study are an age range that includes midlife adults that are the focus of the current US mortality crisis; a multi-dimensional, composite measure of SES that remains comparable over time (even as absolute levels of SES components may change); and health behaviors that include not only smoking but other types of substance abuse (i.e., drug and alcohol) that have been the focus of recent attention.

2. Material and methods

2.1. Data

We use longitudinal data from Waves M1, M2, and M3 of the Midlife in the United States (MIDUS) study. At Wave M1 (fielded January 1995–September 1996), MIDUS targeted non-institutionalized, English-speaking adults aged 25–74 in the coterminous United States (Brim et al., 2019). National random digit dialing with oversampling of older people and men was used to select the main sample ($N = 3487$) and a sample of twin pairs ($N = 1914$). The study also included a random subsample of siblings of individuals in the main sample ($N = 950$) and oversamples from five metropolitan areas in the U.S. ($N = 757$). The response rate for the phone interview ranged from 60% for the twin subsample to 70% for the main sample. Among those who completed the phone interview ($N = 7108$), 6325 (89%) also completed mail-in self-administered questionnaires (SAQs). At Wave M2 (fielded January 2004–August 2005), the MIDUS cohort was re-contacted for a follow-up telephone interview (which was completed by $N = 4963$, 75% of survivors) and SAQ ($N = 4041$, 81% of those who completed the phone interview). Finally, the cohort was re-contacted at Wave M3 (fielded May 2013–June 2014); $N = 3294$ (55% of survivors) completed the telephone interview and $N = 2732$ (83% of those who completed the phone interview) completed the SAQ.

We analyze deaths through May 31, 2013, beyond which mortality follow-up may be incomplete (see Appendix S1 for details). We exclude five respondents for whom the date of death is unknown, leaving 6320 respondents who completed the M1 SAQ. Because the time-varying covariates are updated at M2, we have multiple-record survival data with up to two observations per individual. During the first survival span (M1 to M2), 425 respondents died. The second survival span (M2 to M3) includes 3929 respondents who completed the M2 SAQ, 375 of whom died by May 31, 2013. Thus, our analysis includes 800 deaths.

2.2. Measures

2.2.1. Mortality

In addition to all-cause mortality, we examine mortality from five cause-specific groups (see Appendix S2 for detailed ICD codes). Following Sasson (2016b), the first group includes deaths resulting from causes for which the smoking-attributable fraction is greater than 65% ("Smoking-attributable mortality, years of potential life lost, and productivity losses–United States, 2000-2004," 2008). The other four groups comprise: other cancers; cardiovascular diseases; deaths from all external causes combined with other drug- and alcohol-related deaths (hereafter referred to as external/alcohol/drug); and all other causes (i.e., residual).

2.2.2. Adult SES

We construct a composite measure of SES based on the educational attainment and occupational socioeconomic index (SEI, Hauser & Warren, 1997) of the respondent (and, if applicable, his/her spouse/-partner), household income, and the net assets of the respondent and spouse/partner combined (see Appendix S2 for more details). We dichotomize the sample into low versus high SES at the median because the marginal structural modeling approach is very computer intensive and the results are sensitive to the number of random draws used to assign counterfactual values for a continuous measure of exposure. To avoid potential endogeneity (i.e., substance abuse could affect subsequent income and wealth), we use only the baseline (M1) measure of SES. The low versus high SES groups differ by more than one standard deviation in terms of educational attainment and occupational SEI; they also exhibit large differences in mean household income and assets (Table S1).

2.2.3. Health behaviors

Smoking history (never smoked, former smoker, current smoker), alcohol abuse, and drug abuse are time-varying covariates updated at M2. Alcohol abuse is a dichotomous measure based on four items from the Michigan Alcohol Screening Test (Selzer, 1971) that has been used in previous studies ((Glei & Weinstein, 2019); Ransome et al., 2017). The respondent is coded as exhibiting alcohol abuse if they report any of four alcohol-related problems in the past 12 months: alcohol use in hazardous situations; emotional or psychological problems as a result of alcohol use; strong desire or urge to use alcohol; a great deal of time using/recovering; using more to get the same effect. Drug abuse is a binary measure based on the CIDI-SF Drug Dependence Scale (Kessler, Andrews, Mroczek, Ustun, & Wittchen, 1998) that has also been used in many prior studies (Glei, Stokes, & Weinstein, 2020; Glei & Weinstein, 2019, 2020); ; . The respondent is coded as exhibiting drug abuse if they report any of seven drug-related problems in the past 12 months: role interference as a result of use; use in hazardous situations; emotional or psychological problems as a result of use; strong desire or urge to use alcohol; a great deal of time using/recovering; using more or for longer than intended; using more to get the same effect. Unlike the CIDI-SF, which asks about these drug-related problem if the respondent uses any drug, MIDUS asks these questions only if the respondent reports misuse of a drug (i.e., use of sedatives, tranquilizers, amphetamines, prescription painkillers, inhalants, marijuana/hashish, cocaine/crack/-free base, hallucinogens, heroin, or prescription anti-depressants "on your own"—that is, "without a doctor's prescription, in larger amounts that prescribed, or for a long period than prescribed").

2.2.4. Confounders

We control for a wide range of covariates that are likely to confound the relationship between SES and mortality and the SES-mediator and mediator-mortality relationships. The first group comprises demographic characteristics: age, sex, race (i.e., White, Black, other race), and a time-varying measure of whether the respondent is married or partnered. The initial wave of MIDUS did not ask respondents to report their ethnicity; we could only infer ethnicity based on countries of origin. Yet there are so few Latinx in the MIDUS sample that we have little statistical power to detect racial and ethnic differences in mortality.

Second, we include several measures of the respondent's health in young adulthood, which could affect both adult SES and mortality in later life. At M1, the respondent was asked about his/her physical and mental health at age 16, each of which had a five-point ordinal response scale. Body mass index (BMI) is based on a retrospective (M1) self-report of weight at age 21 and self-reported height.

Third, we control for parental health when the respondent was age 16, which may help capture genetic vulnerability and early life environmental conditions that could influence later life SES and mortality. At M1, the respondent was asked to rate each parent's health on a five-point ordinal response scale. We add dichotomous variables indicating whether his/her mother/father was already deceased.

Finally, we control for childhood SES (see Appendix S2 for details), which is likely to confound the relationship between adult SES and mortality. We split the sample at the median into low versus high childhood SES.

2.3. Analytic strategy

We use standard practices of multiple imputation to handle missing data (Rubin, 1996; Schafer, 1999); see Appendix S3 for more details. We begin by computing age- and sex-standardized mortality rates by SES to demonstrate the magnitude of the disparity in both relative (i.e., ratio) and absolute (i.e., difference) terms. We further disaggregate the data by age group (<65, 65+) to show that when mortality rates are low (i.e., at younger ages), the ratios tend to be high while the absolute differences are low and vice versa.

Next, we investigate whether health behaviors in 1995–96 vary by SES in a way that is consistent with SES disparities in mortality. Smoking patterns differ by cohort (Holford et al., 2014) and substance use varies by age, so we examine how the mediators and the SES differentials in those health behaviors vary by cohort/age.

Then, we use a Cox model with age as the time metric to estimate age-specific mortality controlling for the other confounders. We add smoking and substance abuse in Model 2. Because the MIDUS sample may include multiple people within the same family, we use the robust estimator to correct the standard errors for within-family clustering. In cases where the Schoenfeld residuals suggest the hazards may be non-proportional, we use the "tvc" option in Stata 16 to interact that variable with linear age. Only one of those age interactions is statistically significant ($p < 0.05$): the hazard ratio for childhood SES declines significantly with age for mortality from smoking-related diseases.

Prior studies that examined health behaviors as mediators of the link between SES and mortality relied on the traditional difference approach (Baron & Kenny, 1986) to estimate the indirect effect via mediators, but that method is not generally appropriate in the case of non-linear models. When using a Cox model, one cannot meaningfully compare the parameter estimates with and without a mediator because of non-collapsibility (i.e., the addition of a mediator could shift baseline hazard up or down rather than simply altering the slope of the hazard function) (Di Serio et al., 2009; Lapointe-Shaw et al., 2018; Sjölander et al., 2016). This problem increases as the frequency of the outcome increases (VanderWeele, 2011). Therefore, we use the alternative marginal structural model (MSM) described by Lange et al. (2014, to estimate the natural direct and indirect effects.

If the pathways of the mediators are intertwined, then it is difficult to estimate the individual indirect effects (Lange et al., 2014; VanderWeele & Vansteelandt, 2014). Because there is evidence of dependence between alcohol and drug abuse, we combine them into a single categorical variable (i.e., no abuse, alcohol abuse only, drug abuse only, both alcohol and drug abuse). Our preliminary analyses also suggest that smoking may be intertwined with alcohol/drug abuse. Therefore, we estimate several auxiliary models to test the sensitivity of the indirect estimates for smoking and alcohol/drug abuse. First, we re-estimate single mediator models for smoking and alcohol/drug abuse, which assumes they are independent of each other. Second, we estimate a model that includes not only smoking and alcohol/drug abuse, but also two additional mediators: pain and mental health, both of which have been linked with drug abuse (Glei, Stokes, & Weinstein, 2020; Glei & Weinstein, 2020); and have been implicated as contributors to deaths of despair (Case and Deaton, 2015, 2017). All four of these mediators may be intertwined: for example, pain may lead to drug abuse, but drug abuse can increase pain sensitivity (Ballantyne & Mao, 2003); mental distress may precipitate drug and alcohol abuse, but substance abuse can also exacerbate mental distress (National Institute on Drug Abuse, 2018). As an additional sensitivity analysis, we investigate whether the

results vary by length of mortality follow-up.

3. Results

As expected, the age- and sex-standardized all-cause and cause-specific mortality rates are generally much higher for those with low SES than for those with high SES (Table 1). Because mortality rates are low below age 65, the absolute differences are small even when the relative ratios are high. Whereas the ratios tend to decline with age, the differences generally increase with age. There is one cause for which both relative and absolute SES disparities are small: other cancers (i.e., those not strongly associated with smoking).

Current smoking shows a wide SES differential: prevalence of current smoking in 1995–96 is more than twice as high (and 17 percentage points higher) for those with low SES than those with high SES (Table 2). Those with low SES are also more likely to abuse alcohol or drugs than those with high SES, but the absolute differences are small. For example, the percentage reporting any alcohol/drug abuse in 1995–96 is only two percentage points higher among those with low SES (13%) than those with high SES (11%).

The SES differentials in health behaviors differ by cohort/age (Fig. 1 & Table S3). Among the oldest cohorts (i.e., those born in the 1920s, who are 65–74 in 1995), the percentage who ever smoked is lower for those with lower SES. Among recent cohorts, smoking declines more rapidly at higher levels of SES and thus, the SES gap reverses and widens considerably. The youngest cohorts (i.e., those born in 1960–75) exhibit the largest SES differential in smoking relative to those with high SES: the fraction who ever smoked is 27 percentage points higher and the share who currently smoke is 25 percentage points higher among those with low SES. The SES differentials in alcohol and drug abuse are much smaller in magnitude (i.e., 5 percentage points for alcohol and 7 percentage points for drug abuse among the youngest cohorts).

Tables 3 and 4 show the results from Cox models predicting all-cause and cause-specific mortality. Adjusted for confounders (Model 1), the hazard ratio for low SES is largest for smoking-related mortality (HR = 1.9, 95% CI 1.2–2.9) and all other mortality (HR = 2.0, 95% CI 1.4–3.0), but small and not significant for other cancer mortality. The effect size for SES is similar for cardiovascular (HR = 1.5, 95% CI 1.1–2.0) and external/alcohol/drug-related mortality (HR = 1.5, 95% CI 0.8–2.8), although the latter is not significant, probably because we have few deaths ($N = 48$) from those causes.

Fig. 2 shows the percentage of the SES disparities that are mediated via smoking and alcohol/drug abuse. The indirect effect is largest for mortality from smoking-related diseases (Table S6), where smoking accounts for 62% of the SES disparity. These health behaviors also account for a substantial share of the SES disparity in cardiovascular mortality (41%), but again smoking makes a much bigger contribution (38%) than alcohol/drug abuse (3%). For the residual category of all other mortality, neither smoking (4%) nor alcohol/drug abuse (2%) explains much of the SES gap.

To test the sensitivity of the indirect estimates for smoking and alcohol/drug abuse, we re-estimated the models including each mediator one at a time and including two additional mediators (i.e., pain and mental health). The estimates for the indirect effects remain similar in all cases (Table S7).

When we re-estimate the models for mortality through the end of 2016 (Tables S8 and S9), the SES disparities tend to be slightly smaller than the results presented in Tables 3 and 4. Measurement error resulting from incomplete mortality follow-up could account for the weaker associations. The indirect effects of SES via smoking and alcohol/drug abuse remain similar (Table S7).

4. Discussion

Given the current drug epidemic, it may seem surprising that smoking plays a bigger role than alcohol/drug abuse in SES disparities in mortality, even for external/alcohol/drug-related mortality. Although smoking-related mortality has been declining for the population as a whole, smoking continues to exacerbate SES disparities in mortality because: 1) there is a long lag between smoking initiation and the

Table 1
Age- and sex-standardized all-cause and cause-specific mortality rates[a] (and 95% confidence intervals) by SES and age group.

	SES					
	Low		High		Rate Ratio[b]	Difference
	No.	Rate[a]	No.	Rate[a]	(Low/High)	(Low - High)
All-Cause	480	11.0 (10.0–12.0)	320	6.9 (6.1–7.7)	1.60 (1.38–1.83)	4.1 (2.9–5.4)
Age <65	152	5.0 (4.2–5.8)	93	2.5 (2.0–3.0)	1.99 (1.57–2.63)	2.5 (1.5–3.4)
Age 65+	328	29.4 (26.1–32.7)	227	20.3 (17.6–23.0)	1.45 (1.23–1.72)	9.1 (4.9–13.4)
Smoking-related diseases[c]	85	1.9 (1.5–2.4)	48	1.1 (0.7–1.4)	1.84 (1.29–2.74)	0.9 (0.4–1.4)
Age <65	22	0.7 (0.4–1.0)	9	0.2 (0.1–0.4)	3.16 (1.47–9.88)	0.5 (0.2–0.8)
Age 65+	63	5.6 (4.2–7.1)	39	3.6 (2.4–4.7)	1.58 (1.03–2.43)	2.1 (0.2–3.9)
Other Cancers[c]	97	2.3 (1.8–2.7)	88	1.9 (1.5–2.3)	1.20 (0.91–1.59)	0.4 (−0.2–1.0)
Age <65	34	1.1 (0.7–1.5)	29	0.8 (0.5–1.1)	1.43 (0.87–2.41)	0.3 (−0.2–0.8)
Age 65+	64	5.7 (4.3–7.1)	58	5.2 (3.8–6.6)	1.09 (0.76–1.56)	0.5 (−1.5–2.5)
Cardiovascular[c]	156	3.6 (3.0–4.2)	106	2.3 (1.8–2.7)	1.57 (1.21–2.07)	1.3 (0.6–2.1)
Age <65	40	1.3 (0.9–1.7)	31	0.8 (0.5–1.1)	1.59 (0.99–2.66)	0.5 (0.0–1.0)
Age 65+	116	10.5 (8.5–12.4)	75	6.7 (5.1–8.3)	1.57 (1.15–2.18)	3.8 (1.2–6.4)
External/Alcohol/Drug-Related[c,d]	29	0.7 (0.4–0.9)	19	0.4 (0.2–0.6)	1.68 (0.89–3.21)	0.3 (0.0–0.6)
Age <65	20	0.6 (0.4–0.9)	10	0.3 (0.1–0.4)	2.35 (1.09–5.43)	0.4 (0.0–0.7)
Age 65+	9	0.8 (0.3–1.3)	9	0.8 (0.3–1.3)	1.00 (0.33–2.98)	0.0 (−0.8–0.8)
Other (residual)[c]	98	2.2 (1.8–2.7)	50	1.1 (0.8–1.4)	2.04 (1.44–2.89)	1.1 (0.6–1.7)
Age <65	27	0.9 (0.5–1.2)	9	0.2 (0.1–0.4)	3.73 (1.86–10.2)	0.6 (0.3–1.0)
Age 65+	70	6.3 (4.8–7.8)	42	3.7 (2.5–4.8)	1.71 (1.16–2.52)	2.6 (0.7–4.5)

[a] Per 1000 person-years.
[b] We used bootstrapping with 1000 resamples to compute 95% confidence intervals for the rate ratios.
[c] Cause of death is missing for 24 respondents, who are excluded from the cause-specific analyses.
[d] This group includes deaths for all external causes as well as the other drug- and alcohol-related deaths.

Table 2
Descriptive statistics for mediators at M1 and M2 by low versus high adult SES at M1

Variable	M1 (1995-96)			M2 (2004-05)		
	Adult SES at M1			Adult SES at M1		
	Below Median	Above Median	Total	Below Median	Above Median	Total
Smoking						
Never smoked (%)	41.7	55.8	48.7	42.9	58.4	51.4
Former smoker (%)	28.2	30.9	29.5	35.1	33.3	34.1
Current smoker (%)	30.2	13.3	21.7	22.0	8.3	14.5
Alcohol/Drug abuse						
No abuse (%)	86.5	89.4	88.0	89.7	92.0	91.0
Alcohol abuse only (%)	4.9	4.6	4.7	3.3	3.9	3.6
Drug abuse only (%)	6.1	4.5	5.3	6.0	3.6	4.7
Both alcohol & drug abuse (%)	2.6	1.5	2.1	1.1	0.5	0.8
Number of respondents	3,161	3,159	6,320	1,762	2,167	3,929

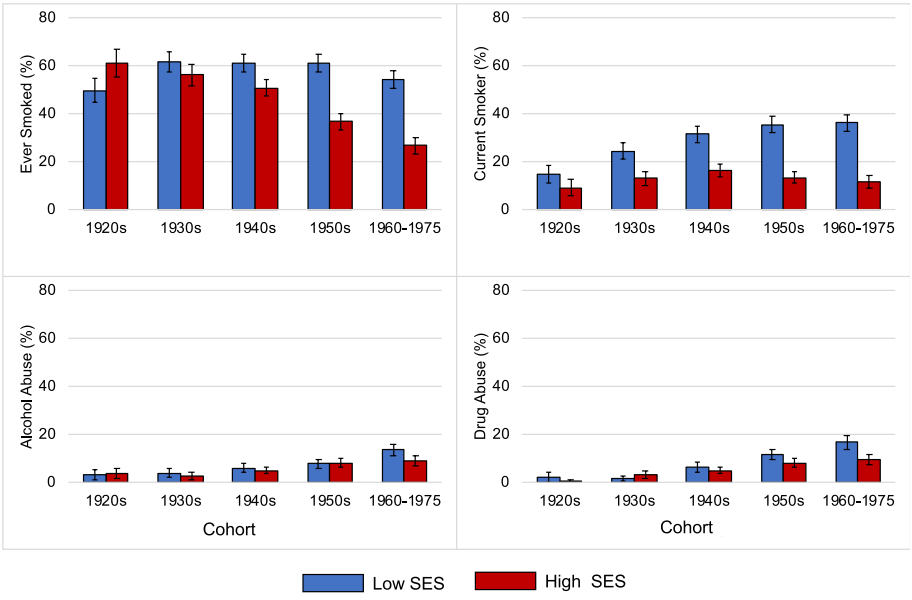

Fig. 1. Prevalence of health behavior mediators at M1 (1995–96) by cohort and SES.

Table 3
Hazard ratios (and 95% Confidence Intervals) from Cox model predicting age-specific mortality from all-causes, smoking-related diseases, and other cancers.

	All-Cause Mortality		Mortality from Smoking-Related Diseases		Other Cancer Mortality	
	(1)	(2)	(1)	(2)	(1)	(2)
Low adult SES	1.57*** (1.33–1.84)	1.45*** (1.23–1.70)	1.91** (1.24–2.94)	1.67+ (0.91–3.07)	1.23 (0.88–1.71)	1.15 (0.83–1.61)
Never smoked	–	–	–	–	–	–
Former smoker	–	1.39*** (1.17–1.66)	–	5.35** (2.26–12.64)	–	1.11 (0.78–1.57)
Current smoker	–	2.99*** (2.45–3.65)	–	19.91*** (8.17–48.48)	–	2.01** (1.33–3.04)
No alcohol/drug abuse	–	–	–	–	–	–
Alcohol abuse only	–	1.10 (0.75–1.62)	–	1.23 (0.45–3.38)	–	1.18 (0.50–2.79)
Drug abuse only	–	1.63** (1.17–2.28)	–	0.96 (0.18–5.05)	–	1.38 (0.61–3.12)
Alcohol & drug abuse	–	2.14* (1.15–3.99)	–	0.00[b]** (0.00–0.00)	–	2.49 (0.64–9.67)
Number of deaths[a]	800	800	133	133	185	185

+ $p < 0.10$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
Note: All models also control for sex, race, married/partnered, the respondent's physical and mental health at age 16, the respondent's BMI at age 21, parental health when the respondent was age 16, and childhood SES (see Table S4 for the full set of coefficients).
[a] The model for all-cause mortality is based on 10,249 observations for 6320 respondents. Cause of death is missing for 24 respondents, who are excluded from the cause-specific analyses, leaving 10,225 observations for 6306 respondents.
[b] No one who abused both drugs and alcohol died of smoking-related diseases, resulting in a very negative coefficient (b = −41.5).

Table 4
Hazard ratios (and 95% Confidence Intervals) from Cox model predicting age-specific mortality from cardiovascular disease, external/alcohol/drug-related causes, and all other causes.

	Cardiovascular Mortality		External/Alcohol/Drug-Related Mortality		All Other Mortality	
	(1)	(2)	(1)	(2)	(1)	(2)
Low adult SES	1.47* (1.09–1.99)	1.37* (1.02–1.86)	1.53 (0.83–2.82)	1.32 (0.73–2.38)	2.02*** (1.36–3.00)	2.01*** (1.36–2.99)
Never smoked	–	–	–	–	–	–
Former smoker	–	1.33+ (0.99–1.78)	–	0.71 (0.32–1.58)	–	1.24 (0.86–1.78)
Current smoker	–	3.02*** (2.10–4.34)	–	2.09* (1.04–4.20)	–	1.28 (0.74–2.24)
No alcohol/drug abuse	–	–	–	–	–	–
Alcohol abuse only	–	1.22 (0.61–2.45)	–	1.29 (0.31-5.27)	–	0.27 (0.04–1.94)
Drug abuse only	–	1.93* (1.12–3.32)	–	1.67 (0.52-5.38)	–	2.28* (1.11–4.67)
Alcohol & drug abuse	–	1.92 (0.57–6.46)	–	10.09*** (4.01-25.34)	–	1.33 (0.18–9.83)
Number of deaths[a]	262	262	48	48	148	148

+ $p < 0.10$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
Note: All models also control for sex, race, married/partnered, the respondent's physical and mental health at age 16, the respondent's BMI at age 21, parental health when the respondent was age 16, and childhood SES (see Table S5 for the full set of coefficients).
[a] Cause of death is missing for 24 respondents, who are excluded from the cause-specific analyses, leaving 10,225 observations for 6306 respondents.

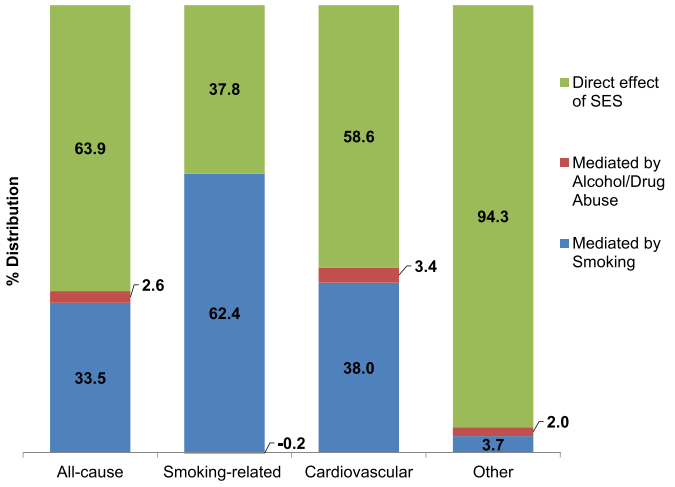

Fig. 2. Percentage of SES disparity in all-cause and cause-specific mortality mediated by alcohol/drug abuse and smoking. Note: See Table S6 for detailed estimates with confidence intervals. Results for other cancer and external/alcohol/drug-related mortality are not shown because the total effect of SES is not significant.

mortality consequences; and 2) smoking prevalence declined earlier and faster for those with higher SES.

In terms of overall life expectancy, men in the US are already beginning to reap the benefits of declines in smoking. Between 2010 and 2020, Preston et al. (2014) estimated that reduced smoking accounted for a 0.54 year gain in life expectancy among men, but only 0.04 of a year for women; by 2040, they project that the gain in life expectancy attributable to smoking will reach 1.5 for men and 0.9 for women. Although the smoking epidemic has waned, its legacy endures, particularly with respect to the implications for SES disparities in mortality.

Smoking initiation often begins at a young age (see Holford et al., 2014, showing that few US smokers start the habit after age 30), but lung cancer rates—which are a good indicator of the impact of smoking—do not peak until around age 70. The cohorts least likely to have ever smoked (those born in 1960–75, aged 35–49 in 2010) are still too young have fully realized the mortality benefits of lower smoking prevalence; the big mortality dividends are not likely to become evident for another 30 years or so (when they are aged 65–79).

There were also SES differences in the evolution of the smoking epidemic. Individuals with higher SES were often early adopters, resulting in little SES disparity in smoking among cohorts who came of age early in the epidemic. As the epidemic progressed, individuals with higher SES were also among the first to stop smoking (or forgo smoking entirely). Thus, SES disparities in smoking began to widen. The cohorts born in the 1930s (aged 70–79 in 2010) are now paying the price of widening SES disparities in smoking compared with previous cohorts. However, younger cohorts are likely to pay an even bigger price in the future because they exhibit even larger SES differences. The widening SES gap in smoking among younger cohorts is consistent with an earlier study showing that the SES differential in lung cancer mortality widened over time (Rubin et al., 2014).

Our results suggest that alcohol and drug abuse play little role in perpetuating SES disparities in mortality. Although drug abuse is associated with increased risk of mortality, the prevalence of drug abuse is highest at younger ages when few people die. At those ages, even a doubling of mortality risk yields only a small absolute increment in mortality rates. Drug abuse declines substantially with age, reaching low levels at the ages when mortality rates are highest. The SES disparities in alcohol and drug abuse are also small in absolute terms, especially at the oldest ages. Consequently, alcohol and drug abuse make little contribution to SES disparities in all-cause mortality because the prevalence of substance abuse is low and SES differences in abuse are small, especially at older ages when most Americans die. External/alcohol/drug-related mortality is the one outcome for which drug and alcohol abuse accounts for a non-negligible share of the SES disparity, although smoking still plays a bigger role.

This study has several strengths. In addition to smoking, we evaluate the mediating effects of alcohol and drug abuse. In auxiliary analyses, we also consider the role of pain and mental health, both of which have featured prominently in the deaths-of-despair literature. Furthermore, we are able to control for many potential confounders that are likely to bias the estimated contribution of health behavior to disparities in mortality by midlife SES; these include not only demographic characteristics, but also childhood SES and early life measures of the health of the respondent and their parents. We also use an advanced MSM strategy that provides more accurate estimates of the joint indirect effect. Finally, we investigate not only all-cause mortality, but also various groups of causes including those expected to exhibit large SES disparities (e.g., mortality from smoking-related diseases and external/alcohol/drug-

related mortality) and much smaller SES disparities (i.e., other cancers that are less closely linked with smoking).

We acknowledge several limitations of this study. First, with 800 deaths, we are unable to examine cause-specific mortality in detail; even when we group deaths of despair with all other external causes, the SES disparity is not significant even though the effect size is comparable to cardiovascular mortality. Similarly, we do not have sufficient power to investigate sex differences even though prior research suggests that the effect of SES on mortality may differ by sex (Chetty et al., 2016) and sex differences in pattern of smoking and substance abuse lead us to suspect their indirect effect may vary by sex. We also suspect that the SES disparities in external/alcohol/drug-related mortality are much larger at younger ages and that alcohol/drug abuse has bigger indirect effects during midlife than in later life, but we do not have sufficient sample size to detect those differences. Second, we cannot determine the temporal order of the influences of pain, mental health, smoking, and substance abuse because they are measured at the same time. Third, any observational study such as this one is likely to underestimate the effect of smoking because of the long lag between the behavior and the mortality consequences and because of imperfect retrospective recall by the respondent. Fourth, it may be impossible to estimate the individual contributions of smoking and alcohol/drug abuse if their pathways are intertwined. Fifth, our self-reported measures of substance abuse are likely to be under-reported. If reporting also varies by SES, it could further bias our estimates. Finally, we recognize that there is potential for omitted variable bias in any observational study. There may be other unmeasured confounders (e.g., tendency toward risk-taking behavior, pre-existing illnesses) that affect our estimates of the indirect effects via smoking and substance abuse.

Once further mortality follow-up data become available, it will be important to re-evaluate the role of drug abuse. Our last measurement of substance abuse comes from M2 (2004–05) and thus, cannot capture the last 15 years of the drug epidemic. Although substance abuse was measured again at M2 (2013–14), we do not yet have complete mortality follow-up beyond that wave. Nonetheless, our data demonstrate growing drug abuse over time, especially among those aged 55 and older in 1995 (i.e., born before 1940). For example, only 1.5% of those born in the 1920s reported drug abuse at M1, but the percentage increased to 6.4% by M3 (Fig. S1). The SES differential in drug abuse also appears to have widened over time. Among the 1920s cohort, the SES differential was 1.1 percentage points at M1, but had grown to 5.4 percentage points by M3 (Fig. S2). Therefore, it would be worth revisiting whether recent widening of the SES differentials in drug abuse contributed to further widening of SES disparities.

5. Conclusions

Drug and alcohol abuse make little contribution to SES disparities in all-cause mortality, probably because substance abuse prevalence is low and SES differences in abuse are small, especially at older ages when most Americans die. In contrast, smoking prevalence is much higher, SES differentials are large and have widened among younger cohorts and thus, smoking accounts for a substantial share of SES disparities in mortality.

These patterns do not bode well for the future. Smoking will continue to be a major source of SES disparities in mortality in the coming decades as cohorts with the largest SES differentials in lifetime smoking grow old enough to suffer the full consequences of behavior they probably initiated during their youth. Given the observed cohort patterns of smoking history, we expect smoking to further widen SES disparities in mortality until at least 2045 for men and even later for women.[1] Although we cannot yet determine the mortality consequences of recent widening of the SES disparities in drug abuse, drug abuse may be exacerbating current SES disparities in midlife mortality more than our analyses suggest. In short, social inequalities in mortality are likely grow even wider over the coming decades as the legacy of smoking and the recent drug epidemic take their toll.

Ethical statement

MIDUS obtained written, informed consent from all participants and received human subjects approval from the Educational and Social/Behavioral Science IRB (institutional review board) at the University of Wisconsin, Madison [#SE-2011-035], and conformed to the principles embodied in the Declaration of Helsinki.

CRediT authorship contribution statement

Dana A. Glei: Conceptualization, Methodology, Software, Data curation, Investigation, Formal analysis, Validation, Visualization, Writing - original draft. **Chioun Lee:** Conceptualization, Methodology, Visualization, Writing - review & editing. **Maxine Weinstein:** Conceptualization, Methodology, Funding acquisition, Project administration, Resources, Supervision, Writing - review & editing.

Declaration of competing interest

None.

Acknowledgments

This work was supported by the National Institute on Aging [grant numbers P01 AG020166, U19AG051426, R00AG052458] and the Graduate School of Arts and Sciences, Georgetown University. We are grateful to Samuel H. Preston and Andrew Stokes for their suggestions on early versions of this manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2020.100699.

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[1] Even among the MIDUS Refresher cohort, the SES differential in the percentage of women who ever smoked is still highest in the youngest cohorts (i.e., born in 1970–89, aged 20–39 in 2010): 29 percentage points higher for low SES (49%) than high SES (20%). Among men, those born in the 1960s exhibit the largest SES difference in the percentage who ever smoked (54% of those with low SES vs. 25% of those with high SES, a differential of 29 percentage points), but the SES disparity declined somewhat among the cohorts born in 1970–89 (to 24 percentage points) [Data not shown]. Thus, we expect smoking history will continue to widen SES disparities in mortality until at least 2045 for men (when the 1960-69 cohorts are aged 75-84) and even later for women.

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