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The Contribution of Drug Overdose to Educational Gradients in Life Expectancy in the United States, 1992–2011

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Abstract

Over the past two decades, the United States has witnessed a dramatic rise in drug overdose mortality. Educational gradients in life expectancy widened over the same period, and it is likely that drug overdose plays a role in this widening, particularly for non-Hispanic whites. The contemporary drug epidemic is distinctive in terms of its scope, the nature of the substances involved, and its geographic patterning, which influence how it impacts different education groups. I use data from vital statistics and from the National Health Interview Survey to examine the contribution of drug overdose to educational gradients in life expectancy from 1992–2011. I find that over this period, years of life lost due to drug overdose increased for all education groups and for both males and females. The contribution of drug overdose to educational gradients in life expectancy has increased over time and is greater for non-Hispanic whites than for the population as a whole. Drug overdose accounts for a sizeable proportion of the increases in educational gradients in life expectancy, particularly at the prime adult ages (ages 30–60) where it accounts for 25–100% of the widening in educational gradients between 1992–2011. Over time, drug overdose mortality has increased more rapidly for females than for males, leading to a gender convergence. These findings shed light on the processes driving recent changes in educational gradients in life expectancy and suggest that effective measures to address the drug overdose epidemic should take into account its differential burden across education groups.

Keywords

Life expectancy; educational gradients; drug overdose

INTRODUCTION

Over the past two decades, the United States has witnessed a dramatic rise in drug overdose mortality. Deaths from drug overdose now exceed deaths from motor vehicle accidents and homicide (Xu et al. 2016). Drug overdose has also been shown to be an important contributor to Americans' life expectancy shortfall relative to other high-income countries (Ho 2013). Between 1994 and 2014, the age-standardized death rate from drug overdose more than tripled, from 4.8 to 14.7 deaths per 100,000 (CDC/NCHS 2015). Over the same period, death rates from motor vehicle accidents and homicides declined by 30–45%. The

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drug overdose epidemic has been primarily driven by prescription opioid painkillers, although deaths in which illicit opioids like heroin and fentanyl are implicated are on the rise, culminating in the "twin" epidemics of opioids and heroin (Paulozzi et al. 2011; Rudd et al. 2016).

Several studies document widening educational gradients in mortality over time (Elo and Preston 1996; Hendi 2015; Meara, Richards, and Cutler 2008; Miech et al. 2011). Studies focusing on trends in the 1990s and 2000s highlight stagnating life expectancy gains among less educated subgroups, particularly for non-Hispanic white women, and continued improvements among more educated subgroups as drivers of widening educational gradients (Hendi 2015; Meara, Richards, and Cutler 2008).

Stagnating life expectancy gains among the less educated coincided with the takeoff of drug overdose mortality in the mid- to late 1990s following FDA approval of the opioid pain reliever OxyContin in December 1995. Increases in drug overdose mortality were especially steep in the early 2000s. While drug overdose death rates rose for most groups, increases were largest for non-Hispanic whites. Between 1999 and 2014, age-standardized death rates from drug overdose increased by 211.5%, 40.0%, and 21.8% for non-Hispanic whites, non-Hispanic blacks, and Hispanics, respectively (CDC/NCHS 2015). Non-Hispanic whites now have higher drug overdose death rates than non-Hispanic blacks and Hispanics. The widening of the educational gradients in life expectancy has also been particularly pronounced for non-Hispanic whites. Thus, it seems likely that the drug overdose epidemic may play a role in the widening of these gradients.

However, no prior studies have examined the contribution of drug overdose to life expectancy differences by education or to the widening of these differences over time. This study uses data from the National Health Interview Survey (NHIS) linked to the National Death Index, combined with data from the National Vital Statistics System, to examine the contribution of drug overdose to educational gradients in life expectancy. I use cause-deleted life table methods to estimate: (1) the years of life lost due to drug overdose by sex and education in four periods: 1992–1996, 1997–2001, 2002–2006, and 2007–2011, (2) the contribution of drug overdose mortality to educational gradients in life expectancy in each of these periods, and (3) the contribution of drug overdose mortality to changes over time in these gradients.

BACKGROUND

The contemporary drug overdose epidemic is distinctive in terms of its scope, its geographic patterning, and the nature of the substances involved. Poisonings deaths, a large fraction of which are drug overdose deaths, reached 51,966 in 2014 and are now the leading cause of injury-related deaths in the U.S., accounting for over a quarter (26.0%) of injury deaths (Kochanek et al. 2016). The respective figures for 1997 were 17,692 deaths and 12.1% (Hoyert, Kochanek, and Murphy 1999). Before the current epidemic, a positive association existed between the level of urbanization and drug overdose mortality. Drug overdose deaths were concentrated in large cities like Baltimore and New York City, which were connected to international drug smuggling networks based in Europe and Turkey. Large central metros had the highest drug overdose death rates – over two and a half times the death rates of the most rural areas, which had the lowest death rates (Paulozzi and Xi 2008). In recent decades, however, this association disappeared. Rural areas and suburbs, which were not profitable markets for illegal drugs prior to the current epidemic, have witnessed the largest increases in drug overdose mortality, and people in rural counties are now more likely to overdose than people in big cities. This is partly related to a fundamental shift in the nature of the substances involved.

In contrast to the heroin and cocaine epidemics of the 1970s and 1980s, which involved illicit drugs, the current epidemic is driven primarily by legally-prescribed drugs. Since the early 2000s, opioid painkillers – particularly OxyContin – have become the leading cause of drug overdose deaths (Paulozzi et al. 2011). In 2007, they were implicated in more overdose deaths than heroin and cocaine combined (Okie 2010). While heroin and other illicit drug use is also increasing and contributing to drug overdose mortality, this has been fueled in large part by users switching from prescription opioids.[1] In 2002–2011, nearly 80% of new heroin users aged 12–49 reported abusing prescription opioids prior to using heroin (Muhuri et al. 2013). In contrast, in the three decades prior to the 2000s the great majority of heroin users reported that heroin was their first opioid of abuse (Cicero et al. 2014).

The roots of the prescription drug epidemic lie in the pain management revolution. Before the 1980s, opioid painkillers were rarely prescribed except for terminally ill cancer patients with chronic pain, and their use was strictly regulated due to fears of addiction. Over the next two decades, however, a sea change in pain assessment and treatment occurred. Pain went from being a neglected phenomenon to being hailed as the “fifth vital sign” starting in 1996, and pain assessments were incorporated in routine health measurements alongside pulse, blood pressure, and temperature (American Pain Society 1999). Several factors contributed to this change, including: (1) the patients’ rights movements, which espoused that freedom from pain is a universal human right and that pain was drastically undertreated in the United States; (2) doctors’ faith in medical progress that we had reached a point where pain could be safely treated by opioid painkillers; (3) campaigns to destigmatize those painkillers; and (4) Purdue Pharma’s aggressive marketing of the opioid painkiller OxyContin as low risk and non-addictive.

This pain revolution culminated in an astronomical rise in the prescribing of opioid painkillers reflected in sharp increases in drug-related emergency department visits, substance abuse treatment admissions, and drug overdose deaths. Sales of opioid painkillers quadrupled between 1999 and 2010 (Paulozzi et al. 2011). This increase in prescribing was not accompanied by increases in the prevalence of patients reporting pain. Between 2000 and 2010, the proportions of emergency department visits and outpatient office visits where pain was the primary symptom or diagnosis remained stable (Daubresse et al. 2013; Chang et al. 2014). However, prescriptions of opioid painkillers increased dramatically while the role of other (non-opioid) therapies was reduced. Factors contributing to the unprecedented amount and diversion of painkillers entering the population include “pill mills,” clinics

[1]This is related to the release of an abuse-deterrent reformulation of OxyContin in 2010 and significant increases in the availability of cheap, high-grade heroin throughout the U.S.

where doctors prescribe extremely large quantities of painkillers for cash; "sponsors" who drive groups of addicts to pain clinics in return for most of the pills they receive, which they in turn resell; and doctor shopping, where patients obtain prescriptions from multiple doctors (McDonald and Carlson 2013; Rigg, March, and Inciardi 2010; Temple 2015). In 2007, the U.S. alone accounted for 83% and 99% of global consumption of the opium derivatives oxycodone (the active ingredient in OxyContin) and hydrocodone, respectively (International Narcotics Control Board 2009). Oher high-income countries have not experienced such severe prescription painkiller epidemics, which may be related to their more conservative attitudes towards painkiller prescribing and less aggressive treatment of chronic disease. Compared to the more fragmented U.S. health care system, health care systems in other countries have greater coordination of care and fewer opportunities for doctor shopping, for-profit clinics, and pill mills.

Drug Overdose and Educational Differences

The linkages between socioeconomic status, of which education is one indicator, and drug use vary across time and space. The typical pattern is for elites[2] to begin experimenting with drugs, which has occurred in the past with substances like cigarettes, cocaine, and opium. Once use diffuses and becomes more widespread in the population, it loses its social cachet, more attention is paid to its negative consequences, and public disapproval mounts (Collins 2005; Ho and Fenelon 2015; Pampel 2001). At this point, use declines and may become stigmatized, criminalized, and/or concentrated among low status groups. In time, these events are forgotten and the cycle repeats (Klaue 1999; Musto 1991). These patterns are consistent with hypotheses from the diffusion of innovations literature, which suggest that the more educated are early adopters and that between-group differences in health behaviors are a function of the stage of diffusion (Pampel 2001; Pampel, Krueger, and Denney 2010). For example, Pampel (2001) finds that the highly educated, among whom smoking was the first to diffuse, had smaller sex differences in cigarette smoking. Thus, one hypothesis, based on the prior literature and historical observation of the linkages between status and patterns of drug use, is that the more educated may have higher drug overdose death rates in the initial stages of the epidemic.

Several distinctive features of the contemporary drug overdose epidemic may influence how it impacts different education groups: the role of the health care system, its rise in rural areas, and its propagation through social networks. First, use of opioid painkillers requires at some point an interaction with the health care system since they are legally-prescribed controlled substances (even if they are eventually diverted). The more educated are more likely to have greater access to the health care system and better insurance policies covering the cost of prescription drugs. On the other hand, cost may be less of a barrier for low educated individuals who qualify for Medicaid or programs like Supplemental Security Income, which usually include Medicaid benefits. They are also more likely to be targeted by and more vulnerable to sponsors who take them to pain clinics, which are easier to access than other parts of the health care system and which dispense large amounts of painkillers for cash.

[2]In this paper, I focus on the more educated as one particular group of social elites.

Following the fundamental cause perspective, drug overdose can be conceptualized as a "proximate" risk factor or cause of death. This perspective suggests that to identify the root sources of health disparities, scholars should look to the broader social conditions which form the context in which proximate behaviors like drug use, diversion, and abuse take place (Link and Phelan 1995). Long-term structural changes in the labor market like deindustrialization have resulted in reduced job opportunities and economic prospects for the less educated. Relative to the more educated, they are more likely to be in poverty, which is a risk factor for drug abuse, and the aforementioned structural changes may incentivize them to participate in the informal economies that emerged around opioid painkillers, particularly in rural areas (Keyes et al. 2014). One study found that OxyContin use was associated with greater social capital in rural Appalachia, hypothesizing that OxyContin may be a means of gaining greater social stature and economic advantages (Jonas et al. 2012).

The proliferation of prescription opioids in rural areas has other implications for educational differences. In general, education levels are lower in rural areas. These areas experienced higher unemployment, higher levels of poverty, and slower recovery after the Great Recession, which may increase vulnerability to drug use. Individuals in rural areas are less likely to live within close proximity to drug treatment programs, which are overburdened and in short supply. Travel distances for emergency responders and to emergency departments are also greater in rural than in more urban areas. This is critical for death from drug overdose, which often occurs as a result of respiratory and/or central nervous system depression. Deaths can be prevented if patients receive life support and naloxone, which reverses the effects of opioids, soon after an overdose occurs. Reaching patients and providing treatment immediately following an overdose is more challenging in rural areas due to lower population density, longer response times, personnel shortages, lack of advanced training opportunities for emergency medical services (EMS) providers, and antiquated equipment (Faul et al. 2015). A recent study suggests that naloxone is underutilized in rural areas, and this may be related to the greater proportion of EMS personnel in rural areas that are certified as basic versus intermediate or paramedic since only 12 states allow EMT-basic personnel to administer naloxone (Ibid.). Less educated individuals are more likely to be exposed to these adverse conditions due to their greater likelihood of living in rural areas. More educated individuals are more likely to live in areas with higher quality, more rapid, and more comprehensive provision of emergency medical services, and they may also be more knowledgeable about the importance of seeking immediate treatment following an overdose.

The fundamental cause perspective focuses on the enduring linkages between socioeconomic status and disease, highlighting the critical role of resources in maintaining these associations (Link and Phelan 1995). In the case of drug overdose, the better educated may possess more resources to combat drug addiction and overdose, including greater access to financial resources, drug treatment programs, and social support networks that can be mobilized to counter drug use. Nonmedical use of prescription opioids is heavily network-based: Jones et al. (2014) documented that for 70.6% of those reporting nonmedical use of opioid painkillers in the past year, friends and relatives were the source of the drugs. The less educated may be more likely to be connected to individuals who have been prescribed painkillers or who participate in drug diversion through their social networks. For example, in rural communities, the nature and importance of family and community networks tend to result in wide social networks consisting of strong ties, facilitating the diversion and spread of prescription opioids (Keyes et al. 2014). Less educated individuals are more likely to be in poorer health, work in blue collar occupations such as mining and manufacturing where they may incur work-related injuries and disabilities, and have more chronic conditions, particularly pain-related conditions. This increases the likelihood of their being prescribed opioids painkillers and high dosages of opioids, which are associated with greater risks of fatal drug overdose (Bohnert et al. 2011).

Thus, it is likely that the burden of drug overdose mortality is differentially distributed across education groups. However, few studies have examined this question. This paper seeks to estimate the magnitude of educational differences in drug overdose mortality and demonstrate how they have changed over time. These analyses shed light on the processes affecting the size of and trends in contemporary educational gradients in life expectancy in the United States.

DATA

I use vital statistics and survey data to estimate the burden of drug overdose mortality by education. First, I estimate the fraction of all deaths due to drug overdose (DO) using the CDC/NCHS Multiple Cause-of-Death (MCD) micro-data files (NCHS):

$$r_{isep}^{DO} = \frac{D_{isep}^{DO}}{D_{isep}^{Total}} \quad (1)$$

where D is the number of deaths, i is age (25–29, …, 80–84, 85+), s is sex, e is education (less than high school, high school completion, some college, college or more), and p is period. The “some college” and “college or more” categories correspond to having 1–3 years or 4 or more years of college, respectively, defined based on years of education (for states using the 1989 revision of the death certificate, NHIS prior to 1996) or highest degree attained (for states using the 2003 revision of the death certificate, NHIS from 1997-onwards).

Drug overdose deaths are defined according to the standard NCHS category of drug poisoning deaths (Warner et al. 2011; Rudd et al. 2016).[3] This is the most precise and reliable definition of drug overdose deaths because: (1) it includes deaths from both legal and illegal drugs; (2) it excludes drug-related deaths unlikely to be related to opioids (e.g., drug-induced obesity or poisonings due to pesticides) whose inclusion would lead to overestimates of drug overdose mortality; (3) and it includes drug-related deaths regardless of intentionality, including accidents, suicides, and deaths of undetermined intent (including only a subset of these deaths such as accidental poisoning would lead to underestimates of drug overdose mortality).

[3]These are deaths for which the underlying cause of death was ICD-9 codes E850–E858, E950.0–E950.5, E962.0, or E980.0–E980.5 prior to 1999 and ICD-10 codes X40–X44, X60–X64, X85, and Y10–Y14 from 1999-onwards.

Completeness of education reporting on death certificates has varied over time and across states (Rostron, Boies, and Arias 2010). I conduct a sensitivity analysis by calculating life expectancy in the absence of drug overdose using data from all states with any education reporting, from states with at least 90% completeness of education reporting, and from the 34 states with at least 90% completeness since 1992. Differences across these variants are minimal and never exceed 0.01 years (Appendix Table 1). The results in the main text are based on all available data.

Second, I estimate all-cause death rates by age, sex, education, and period (m_{isep}) from weighted counts of deaths and quarter-years of exposure using the NHIS (Minnesota Population Center and State Health Access Data Assistance Center 2015). I use the NHIS because calculating education-specific death rates from death certificates and census population counts is problematic due to dual data source bias from education misreporting on death certificates (Hendi 2016; Rostron, Boies, and Arias 2010; Sorlie and Johnson 1996). The NHIS is representative of the U.S. civilian noninstitutionalized population. I use data on individuals surveyed between 1986 and 2009 who contributed deaths and person-years during four periods, one prior to the takeoff in drug overdose mortality (1992–1996) and three subsequent (1997–2001–2002–2006, and 2007–2011). Individuals are allowed to contribute a maximum of 10 years of exposure, or are censored at time of death or on December 31, 2011.

Finally, I apply the ratios of drug overdose to total deaths from vital statistics to the death rates from the NHIS to obtain drug overdose death rates by age, sex, education, and period:

$$m_{isep}^{DO}=r_{isep}^{DO} * m_{isep}. \quad (2)$$

Drug overdose death rates by education cannot be calculated directly from the NHIS for several reasons. First, the cause of death categories available in the NHIS do not allow for precise identification of drug overdose deaths, as these categories include causes one would like to exclude (e.g., motor vehicle accidents) and exclude causes one would like to include (e.g., opioid poisoning deaths of undetermined intent). Second, even if one were to use these broad categories, the number of deaths would be too small to derive stable estimates.[4] Thus, the combination of vital statistics and survey data used in this paper is the most reliable way to calculate nationally-representative, education-specific drug overdose death rates.

METHODS

I use standard life table methods to calculate life expectancies by sex, education, and period (e_{sep}) using all-cause death rates from the NHIS (m_{isep}) and ${}_na_x$ values of 2.5. The death rates are converted to probabilities of dying (p_{isep}) to construct these life tables.

Next, I calculate life expectancies by sex, education, and period in the absence of drug overdose deaths (e_{sep}^{-DO}) using cause-deleted life tables based on Chiang's approach (Chiang

[4]There were fewer than 700 accidental poisoning deaths in the 1986–2004 NHIS files.

1968; Preston, Heuveline, and Guillot 2001). To construct these cause-deleted life tables, ${}_na_x$ values are derived using graduation techniques, and the probabilities of dying in the absence of drug overdose are calculated as:

$$p_{isep}^{-DO}=[p_{isep}]^{(1-r_{isep}^{DO})}. \quad (3)$$

This equation is derived from Chiang's assumption, which posits that within each age group, the instantaneous death rate in the absence of a particular cause of death is proportional to the observed instantaneous death rate. In this case, the cause of death is drug overdose and the constant of proportionality is $1-r_{isep}^{DO}$. In other words, within each age group, the death rates in the absence of drug overdose have the same shape as the observed death rates but differ in terms of level. Interested readers seeking further details are encouraged to consult Beltran-Sanchez, Preston, and Canudas-Romo (2008) and Preston, Heuveline, and Guillot (2001).

I compare two quantities from these life tables in the presence (observed) and absence (counterfactual) of drug overdose: life expectancy at age 25 $(e_{25}$ vs. $e_{25}^{-DO})$ and years of life lived between ages 30 and 60 $({}_{30}L_{30}$ vs. ${}_{30}L_{30}^{-DO})$.[5] If drug overdose no longer operated as a cause of death, people would live longer than we actually observe ($e_{25}^{-DO} \geq e_{25}$ and ${}_{30}L_{30}^{-DO} \geq {}_{30}L_{30}$). Thus, years of life lost due to drug overdose (YLL) are calculated as:

$$YLL_{25+}=e_{25}^{-DO}-e_{25} \quad (4a)$$

$$YLL_{30-60}={}_{30}L_{30}^{-DO}-{}_{30}L_{30} \quad (4b)$$

for each sex-education-period combination (the *sep* subscripts are omitted for clarity). These quantities are used to determine the contributions of drug overdose to educational gradients in life expectancy in each period and to changes in educational gradients in life expectancy over time. For example, the percent of the educational gradient in life expectancy between high school and college graduates due to drug overdose in a given period is:

$$\frac{(e_{25|COL}-e_{25|HS})-(e_{25|COL}^{-DO}-e_{25|HS}^{-DO})}{e_{25|COL}-e_{25|HS}}*100. \quad (5)$$

[5]The latter measure is informative because it captures the ages at which drug overdose mortality rates are highest and have increased the most over time (see Appendix Figure 1), and it is less sensitive to issues of age misreporting and changes in institutionalization at older ages.

I calculate these quantities for the total population and for non-Hispanic whites alone since drug overdose death rates are higher[6] and educational gradients in life expectancy tend to be larger for non-Hispanic whites.

Cause-deleted life tables compute life expectancy in the absence of all drug overdose mortality. To shed more light on the dynamics linking drug overdose and educational gradients, I examine two additional counterfactuals that answer the following questions: (1) What would educational gradients in life expectancy look like if all education groups maintained their drug overdose death rates from the earliest period (1992–1996)? and (2) What would educational gradients in life expectancy look like if the other three education groups experienced the drug overdose death rates of the college-educated in each period? In these counterfactuals, mortality rates from all other causes excluding drug overdose are unchanged from the observed rates in each period (i.e., all variation is derived from changes in drug overdose death rates).

RESULTS

Drug Overdose Mortality by Education

Drug overdose has become a major cause of death in certain age groups. In 1992, drug overdose accounted for 4.4–5.4% of all deaths among high school graduates and 2.4–4.5% of all deaths among college graduates between ages 25–34 (see Appendix Table 2). By 2011, these figures reached roughly 20% for high school graduates and 10–16% for college graduates. These fractions are higher for non-Hispanic whites than for the total population. The highest fraction was observed for non-Hispanic white females aged 25–29 with less than a high school education in 2010, among whom fully one-third of all deaths were due to drug overdose. In 1992, this figure was only 5.6%. Overall, however, death rates at these ages are much lower than at other ages, so we proceed to examine age-standardized death rates and life expectancy measures.

Figure 1 shows age-standardized drug overdose death rates by education for males (panel A) and females (panel B). In the earliest period, 1992–1996, there existed a negative educational gradient in drug overdose mortality among males. Death rates ranged from 3.2 per 100,000 among college graduates to 14.0 per 100,000 among those with less than high school. Among females, those with less than high school had higher drug overdose death rates, but death rates among the other three education groups were fairly similar. In this period, drug overdose death rates were very similar for the total population and for non-Hispanic whites across all education levels.

The next period, 1997–2001, covers the years directly following the introduction of OxyContin. Compared to the first period, drug overdose death rates are higher for all education groups, with larger increases observed among those with a high school degree or

[6]This is in part related to differences in opioid prescribing by race/ethnicity. Blacks, Hispanics, and Asians are less likely than whites to receive opioid prescriptions, even controlling for pain severity (Burgess et al. 2014; Pletcher et al. 2008). Even when they are prescribed opioids, they are more likely to live in areas where they cannot obtain them. One study in New York City found that only 25% of pharmacies in predominantly nonwhite neighborhoods carried sufficient supplies of opioids to treat severe pain compared to 72% of pharmacies in predominantly white neighborhoods (Morrison et al. 2000).

less and for non-Hispanic whites compared to the total population. A more graded association between education and drug overdose begins to emerge among females.

In the third period, 2002–2006, we continue to see a pattern of steeper increases in drug overdose mortality at the lower end of the education distribution. This is particularly true for non-Hispanic whites, among whom the less than high school group pulls away from the other education groups in this period.

By the most recent period, 2007–2011, drug overdose death rates reached 25.1–29.5 per 100,000 among those with less than high school in the total population and 44.2–50.3 per 100,00 among non-Hispanic whites with less than high school. These range from two- to five-fold increases compared to the earliest period. Among college graduates, drug overdose death rates increased over time, but in the most recent period they are still lower than rates observed in the first period for the least educated.

Drug overdose death rates for males and females converged over this time period. Initially, for all three education groups with less than a college degree, drug overdose death rates were roughly two times higher for males than females. By the most recent period, however, the ratio of male to female death rates was much closer to parity. This occurred for both the total population and for non-Hispanic whites. Trends differed among college graduates, whose drug overdose death rates were near parity to begin with. Among college graduates, male drug overdose death rates increased more quickly than female drug overdose death rates, resulting in a peak in the ratio of male to female drug overdose death rates at 1.7 in 2002–2006. Between 2002–2006 and 2007–2011, however, drug overdose death rates increased more rapidly among college-educated females, bringing the ratio back in the range of 1.0–1.2.

Years of Life Lost due to Drug Overdose by Education

Table 1 shows the years of life lost due to drug overdose (YLL) at ages 25+ and between ages 30–60 by education for males (panel A) and females (panel B).

In general, there is an inverse association between YLL and education, with those with less than high school losing the most years of life from drug overdose and the college-educated losing the fewest years of life from drug overdose. Differences among those with a high school diploma, some college, and college or more are muted among females until after the takeoff in drug overdose mortality (i.e., the educational gradient in YLL widens starting in the 1997–2001 period for females). In the earliest period, YLL above age 25 by education range from 0.11–0.24 years for males and 0.10–0.18 years for females. In the most recent period, the corresponding ranges are 0.17–0.79 and 0.16–0.75 for males and females, respectively.

Initially, YLL were very similar for the total population and for non-Hispanic whites. Over time, however, they increased more rapidly among non-Hispanic whites than for the total population among the three lower education groups. For example, YLL increased from 0.24 to 0.46 years for males with less than high school in the total population between 1992–2011. For their non-Hispanic white counterparts, YLL increased from 0.24 to 0.79 years.

Among the college-educated, however, YLL remain similar for the total population and for non-Hispanic whites.

The patterns and trends in YLL between ages 30–60 are similar to those at ages 25+. A large proportion of YLL due to drug overdose mortality above age 25 occurs at ages 30–60. Across all periods and education groups, YLL between ages 30–60 account for 19–52% and 17–41% of all YLL above age 25 for males and females, respectively.

Contribution of Drug Overdose to Educational Gradients in Life Expectancy

Next, I translate these differences in YLL due to drug overdose into their contributions to educational gradients in life expectancy. Table 2 shows the gradient, or the observed difference in life expectancy at age 25 (or years of life lived between ages 30–60) between each education group and the college-educated, and what percentage of the gradient is due to drug overdose in each period. These percentages reflect differences between the observed and cause-deleted life tables – in other words, in the absence of drug overdose, educational gradients in life expectancy would be smaller than we observe.

In the earliest period, drug overdose made minimal contributions (ranging from 0.5–1.7%) to educational gradients in life expectancy at age 25, and these were similar for the total population and non-Hispanic whites. By the most recent period, the contributions increased to 2.7–6.3% and were greater among non-Hispanic whites. Interestingly, for life expectancy at age 25, drug overdose often makes a larger relative (percent) contribution to the differences between the most and intermediate educated (e.g., college-educated vs. some college or high school) than to the differences between the most and least educated (e.g., college-educated vs. less than high school). However, the absolute contributions of drug overdose are higher in the latter case because life expectancy differences between the college-educated and those with less than high school are larger.

Drug overdose makes a larger percent contribution to educational gradients at ages 30–60, ranging from 5.3–6.4% and 4.6–8.1% for males and females, respectively, in the earliest period. Increases in these contributions occurred in the late 1990s and were particularly large in the 2000s. In the most recent period, the contribution of drug overdose to life expectancy gradients reached upwards of 10% for all education groups in the total population. This contribution was even larger among non-Hispanic whites. In 2007–2011, the contribution of drug overdose to educational gradients in life expectancy reached 15% and 20% for non-Hispanic white males and females, respectively.

Initially, the contribution of drug overdose to educational gradients in mortality was generally larger for males than females. Over time, however, drug overdose accounts for an increasingly greater proportion of educational gradients among females. This is true for both years of life lived between ages 30–60 and life expectancy at age 25, and it is somewhat more pronounced among non-Hispanic whites. Taking the less than high school and college graduate groups as an example, we see that among non-Hispanic whites in 1992–1996, drug overdose accounted for 5.8% of the gradient for males and 5.6% of the gradient for females at ages 30–60. In 2007–2011, these figures were 15.4% and 19.1%, respectively.

Contribution of Drug Overdose to Changes in Educational Gradients in Life Expectancy

Table 3 shows the contribution of drug overdose to changes in educational gradients in life expectancy over time. These contributions are determined based on comparing the observed changes in educational gradients to how they would have changed in the absence of drug overdose. In a few cases, the gradient narrowed over time (i.e., the change in the gradient was negative), and in the absence of drug overdose, the gradient would have narrowed even more. In some cases, the contribution reaches 100%, indicating that the gradient would not have increased were it not for drug overdose (i.e., implying that drug overdose accounts for all of the change in the gradient). These are all cases in which changes in gradients were very small, increasing by less than a tenth of a year. This occurs more often for the contrast between the some college and college graduate groups, for which the smallest differences in life expectancy are observed, and for years of life lived between ages 30–60 versus life expectancy at age 25. Clear attribution of such small changes in life expectancy gradients is difficult, so in the discussion and interpretation of the results, I focus on cases for which we observe meaningful changes in life expectancy gradients.

Drug overdose makes sizeable contributions to changes in educational gradients in life expectancy, and these contributions are larger for non-Hispanic whites than the total population. Between 1992–1996 and 2007–2011, the difference in life expectancy at age 25 between the least and most educated non-Hispanic whites increased by 3.45 years for males and 4.27 years for females. Drug overdose accounted for 11.9% and 14.2% of these increases. Differences in life expectancy at age 25 between those with some college and those with college or more increased by 1.14 years for males and 0.65 years for females, with drug overdose accounting for 16.7% and 19.3% of these increases.

For males, the percent contributions of drug overdose to changes in educational gradients in life expectancy remained fairly stable across time. For example, focusing on the change in the gradient in life expectancy at age 25 between non-Hispanic whites with less than high school and those with college or more, we see that contributions of drug overdose to the change between each of the three earlier periods and 2007–2011 are 14.2%, 12.5%, and 14.5%. For women, the contributions to the changes between the first two periods (1992–1996 and 1997–2001) and the most recent period are fairly similar. However, the contribution of drug overdose tends to be much larger between 2002–2006 and 2007–2011.

For the population as a whole, longer-run trends in educational gradients in life expectancy between ages 30–60 have actually been quite favorable for men. In many cases, gradients decreased between 1992–1996 and 2007–2011. Between the two most recent periods, however, the gradients for less than high school and high school increased, with drug overdose accounting for 21% of the 0.18-year increase in the gradient for high school graduates. Non-Hispanic white males experienced consistent increases in educational gradients in life expectancy at the prime adult ages. For all three education groups, drug overdose accounted for upwards of 70% of the widening in the gradient between 1992–1996 and 2007–2011 and for 21–45% of the widening between the two intermediate periods and the most recent period.

For the female population as a whole, changes in educational gradients in life expectancy at ages 30–60 were fairly minimal. Where we did observe increases, the contribution of drug overdose was sizeable, upwards of 25%. Non-Hispanic white females saw large increases in educational gradients in life expectancy at ages 30–60, with the largest increase observed for those with less than high school between 1992–2011. Drug overdose accounted for 42.3% of this 0.47-year increase. Among non-Hispanic white females, drug overdose accounted for 26.4–63.7% of increases in educational gradients in life expectancy at these ages.

Two Additional Counterfactuals

Finally, I examine two counterfactuals that further illuminate these results. Which scenario would result in greater gains in years of life lived, if all groups returned to their drug overdose mortality rates from the earliest period (prior to the drug overdose epidemic) or if they had the drug overdose mortality rates of the college-educated in each period?

Figure 2 shows the years of life that would be gained by education group in each of these two scenarios for males (panel A) and females (panel B). The escalation of the drug overdose epidemic is reflected in the increasing bar heights over time.

For males, the answer is clear: in each period, it is more favorable to have the drug overdose death rates of the college-educated in that period (i.e., the heights of the blue bars are greater than the red bars). However, the difference between the scenarios erodes over time. The difference in years of life gained between the two scenarios is largest in 1997–2001, the initial takeoff period for the drug overdose epidemic. In the two most recent periods, the years of life gained in the first scenario (the heights of the red bars) increase, and the years of life gained begin to converge between the two scenarios. There are some cases, usually for the some college group, where the years of life gained in each scenario are nearly equal.

For females, the story is similar to that for males in the earlier periods (all education groups would gain more years of life if they had the drug overdose mortality rates of the college-educated), but differs in the most recent period. In the most recent period, the high school and some college groups would gain *more* years of life if they reverted to their baseline drug overdose death rates than if they had the contemporaneous drug overdose death rates of college-educated females.

DISCUSSION

Over the past two decades, educational gradients in life expectancy widened, and dramatic increases in drug overdose mortality occurred. In this paper, I show that drug overdose accounts for much of the widening in educational gradients in life expectancy between 1992–2011. Over this period, we observe a divergence between the college-educated and the three lower education groups, which experienced large increases in drug overdose mortality. The contribution of drug overdose to educational gradients in life expectancy is largest at the prime adult ages (ages 30–60) and for non-Hispanic whites.

The contribution of drug overdose to educational gradients in life expectancy at ages 30–60 is substantial and has doubled (for males) and tripled (for females) over time. In the most recent period, drug overdose accounts for roughly 16–18% of the difference in life expectancy between non-Hispanic white high school and college graduates aged 30–60. Among non-Hispanic whites aged 30–60, drug overdose accounts for over 70% of the widening in educational gradients in life expectancy among males and for 26–62% of the widening among females between 1992–2011.

A priori, one might expect the more educated to have higher levels of drug use in the early stages of an epidemic: elites are typically on the vanguard of drug use (Collins 2005; Pampel 2001) and in the context of an epidemic driven by prescription painkillers, it is likely that the more educated were among the first to be prescribed newly-approved prescription opioids and better able to afford them. However, we do not observe higher drug overdose mortality among the college-educated in the context of the current drug epidemic. Instead, drug overdose mortality is higher and has increased most for the three lower education groups. This suggests that either use is lower among the college-educated and/or that the consequences of use in terms of mortality are very different for the more versus less educated.

Higher levels of drug overdose mortality among the less educated may be driven by several factors. First, relative to the more educated, the less educated are more vulnerable to and have greater incentives to engage in drug use. In the face of deindustrialization and other structural changes in labor markets that lowered the returns to education levels below a college degree, the less educated experienced declines in employment prospects, socioeconomic status, and overall well-being (Kalleberg 2011; Weeden et al. 2007). Consequently, they are more susceptible to being targeted by sponsors who organize groups of users to obtain drugs from pill mills and have greater incentives to participate in the informal economies surrounding the diversion of OxyContin and other opioids (Keyes et al. 2014). Second, less educated individuals face increased risk of workplace injuries, disability, and chronic health conditions (Minkler et al. 2006; Oh and Shin 2003; Seeman et al. 2008), which lead to greater likelihood of being prescribed opioid painkillers. Third, higher drug overdose mortality among the less educated may be related to the geographic shift in drug overdose from cities to rural areas, especially in Appalachia and the Rust Belt. Rural areas have lower levels of educational attainment, experienced recent declines in socioeconomic well-being, and have poorer EMS infrastructure (Faul et al. 2015). The motivation for and returns to self-medication may be increased in such areas. Finally, the less educated may have fewer resources to combat drug addiction, including financial resources, access to scarce slots in drug treatment programs, and support from social networks.

A particularly interesting finding of this study is the gender convergence in drug overdose. Historically, males had higher drug overdose death rates. In the course of the present epidemic, drug overdose mortality has converged between males and females, driven by more rapid increases among females. If we ask whether it is more favorable (in terms of years of life gained) for each group to return to their drug overdose death rates observed prior to the takeoff of the current epidemic or to have the drug overdose death rates of the college-educated, the answer differs for males and females. For males, it is always better to have the drug overdose mortality of the college-educated. For females in the most recent period, however, it is better for the some college and high school groups to return to their baseline levels than to have the contemporaneous death rates of the college-educated. This suggests that while educational gradients in drug overdose mortality remained fairly sharp for males, females experienced large increases in drug overdose mortality across all education levels over the course of the epidemic.

These gender differences may be due to differences in health-seeking behaviors and in social and biological dimensions of substance use and addiction. While men are more likely to use illicit drugs and alcohol, women are more likely to engage in nonmedical prescription drug use (Simoni-Wastila, Ritter, and Strickler 2004). A study of all pharmaceutical overdose deaths that occurred in 2006 in West Virginia, which had the greatest increase in drug overdose mortality in 1999–2004, found that evidence of doctor shopping (having prescriptions for a controlled substance from five or more doctors in the year prior to death) was much more common among female (30.9%) than male (16.7%) decedents (Hall et al. 2008). This may be related to factors including women's greater connectedness to the health care system and higher levels of stigma and social disapproval towards illicit substance use for women than for men (Robbins 1989). While overall rates of substance use are higher among males, females appear to have more rapid escalation of drug use, become addicted more quickly, and have more difficulty quitting once addicted (Becker and Hu 2008). On the other hand, women are also more likely to seek treatment for substance use addictions and to do so earlier than men. Other contributing factors include gender differences in competing risks and trends in educational attainment. At the young and prime adult ages where drug overdose mortality is highest, males have higher death rates from other causes of death. Furthermore, educational upgrading has been more dramatic for females than males, such that among females, the less educated, particularly the less than high school group, are more select than corresponding groups among males.

Limitations

Over time, education levels have increased in the U.S., altering the population distribution across education groups (Hendi 2015). One consequence of this compositional change is that the less educated have become increasingly select, affecting the comparison of education groups over time. It is likely that consequences of educational upgrading such as worsening employment prospects and stagnating economic conditions for those with a high school degree or less are also key factors in the rise in drug overdose, and disentangling their separate influences is a complicated endeavor. This study does not account for these compositional changes, and caution should be taken in interpreting how drug overdose contributes to changes in educational gradients in life expectancy. The results pertaining to years of life lived between ages 30–60 are less sensitive to this issue since they make comparisons among individuals at most 30 years apart in age.

By necessity, this study relies on education reported on death certificates to estimate the fraction of all deaths due to drug overdose because sample sizes for drug overdose deaths based on survey data are too small to allow for stable estimates. To the degree that some error is introduced, it is introduced in both the numerator and the denominator of these fractions (i.e., it is not subject to dual data source bias). This concern may be mitigated by the fact that education reporting on death certificates is considered to be more accurate at ages below 65 (Rostron, Boies, and Arias 2010), where the bulk of drug overdose mortality occurs.

Finally, it is possible that drug overdose is undercounted on death certificates (see Paulozzi et al. 2006 for a fuller discussion). This would likely result in underestimates of years of life lost due to drug overdose, so the estimates in this paper may be lower bounds. On the other hand, risky behaviors such as drug use, smoking, and alcohol use tend to cluster. It is possible that some drug overdose deaths had multiple contributing factors or had these individuals not died of drug overdose, they would eventually have died of smoking- or alcohol-related causes. These possibilities might lead to overestimates of drug overdose mortality.

CONCLUSION

This study documents increases in years of life lost due to drug overdose for all education groups and for both males and females over the past two decades. The contribution of drug overdose to educational gradients in life expectancy has increased over time, is larger at the prime adult ages (ages 30–60), and is greater for non-Hispanic whites than the population as a whole. Drug overdose accounts for a substantial proportion of changes in educational gradients between 1992–2011, particularly among non-Hispanic whites at ages 30–60. Over time, drug overdose mortality increased more rapidly for females than males, leading to a gender convergence.

These findings have important implications. Overall, they suggest that effective measures to address the drug overdose epidemic should take into account the differential burden across education groups. For example, drugs are increasingly being used to treat drug addiction. A recently proposed option, implants that release buprenorphine to treat opioid addiction, must be replaced every six months by a trained doctor (Bebinger 2016). These and other addiction treatments being used are very expensive, and cost and access barriers for the less educated are likely to be substantial. Finally, while the drug overdose epidemic was initially driven by prescription painkillers, it has moved on to encompass heroin and synthetic opioids. In order to effectively address the epidemic and its contribution to educational gradients in life expectancy, we need to concentrate on the underlying factors that may be driving drug use, including poor social and labor market conditions. An important avenue for future research is to explore the linkages between gender and drug overdose, encompassing males' initially higher mortality from drug overdose and the subsequent gender convergence.

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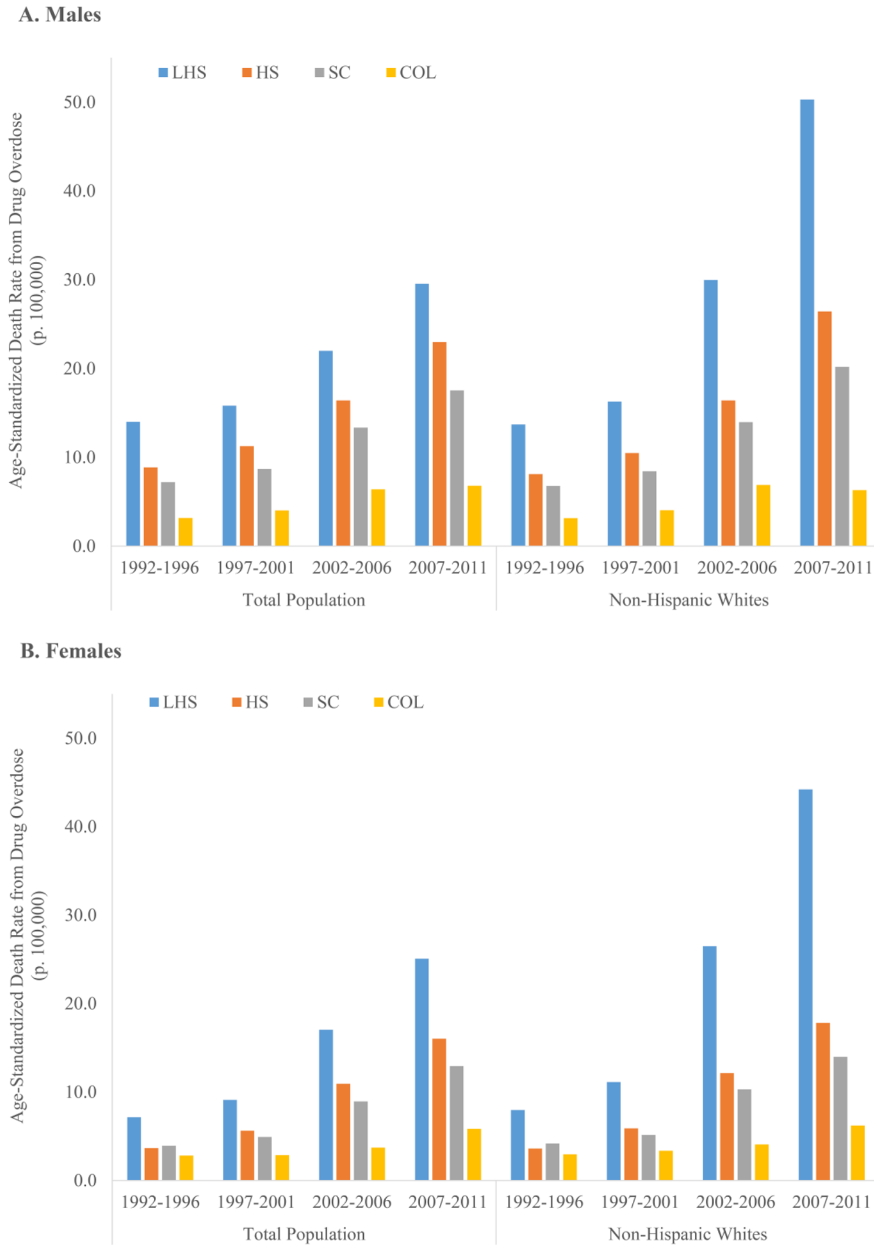


Figure 1.

Age-standardized death rates (p. 100,000) from drug overdose by education, 1992–2011

Note: Estimates are based on data from the CDC/NCHS Multiple Cause-of-Death files and the National Health Interview Survey (NHIS). LHS=Less than high school, HS=High school, SC=Some college, COL=College or more.

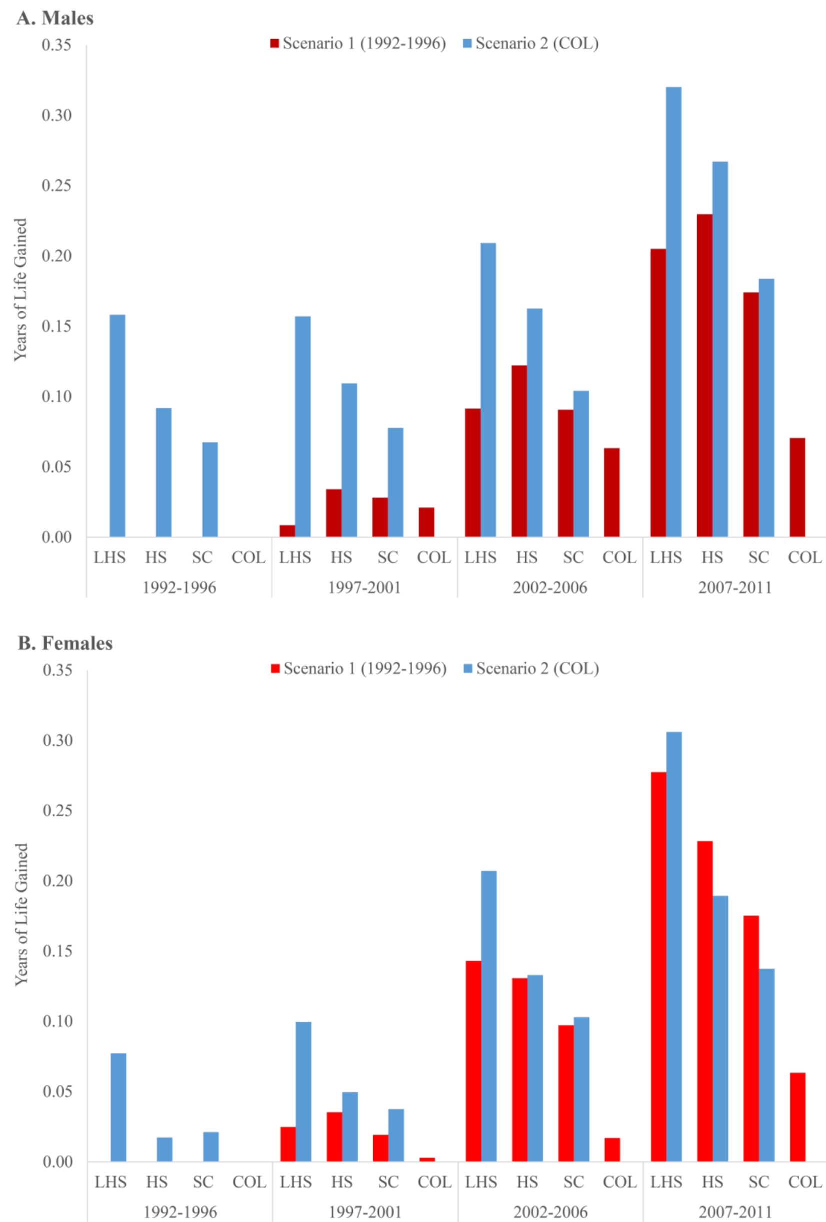
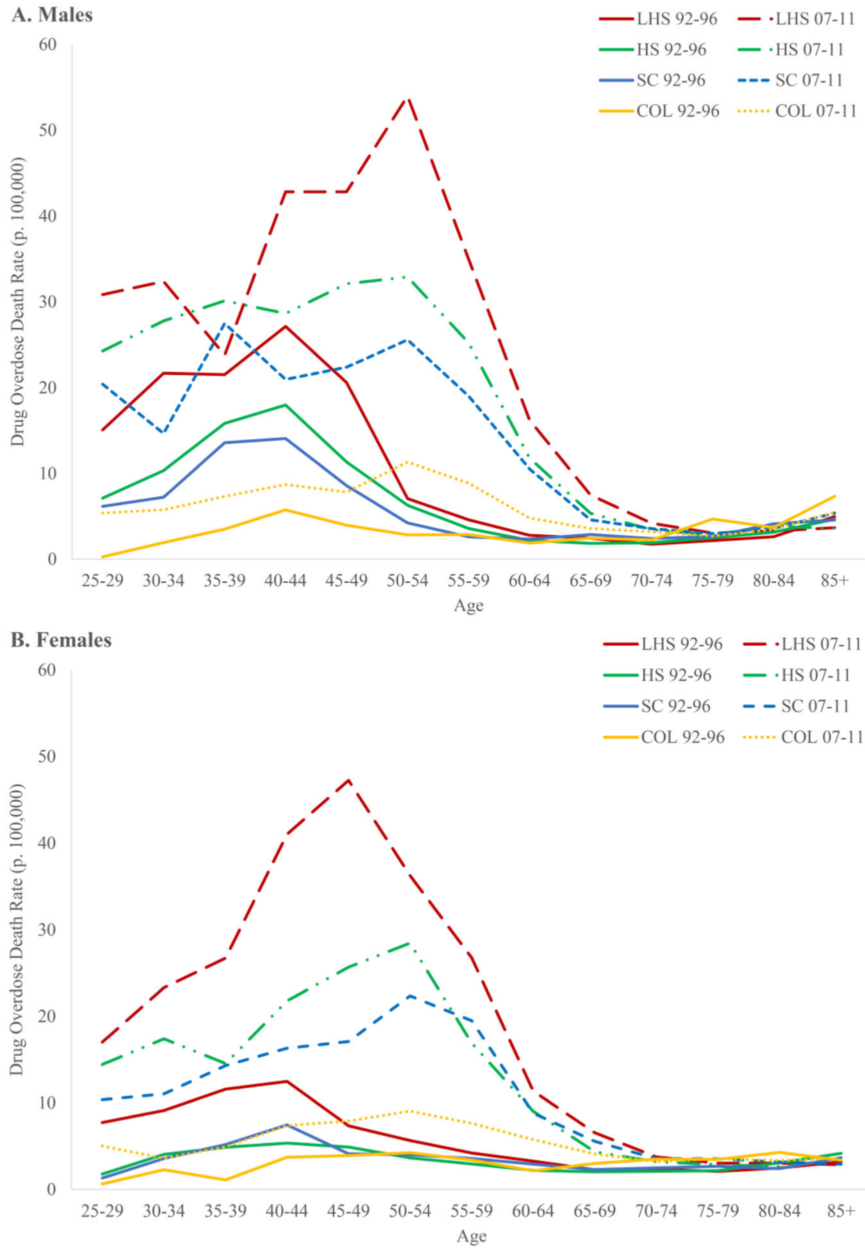


Figure 2.

Years of life gained at ages 25+ by education, two counterfactual scenarios, 1992–2011

Note: Estimates are based on data from the CDC/NCHS Multiple Cause-of-Death files and the National Health Interview Survey (NHIS). LHS=Less than high school, HS=High school, SC=Some college, COL=College or more.



Appendix Figure 1.

Age-specific death rates (p. 100,000) from drug overdose by education, 1992–1996 and 2007–2011

Note: Estimates are based on data from the CDC/NCHS Multiple Cause-of-Death files and the National Health Interview Survey (NHIS). LHS=Less than high school, HS=High school, SC=Some college, COL=College or more.

Table 1

Years of life lost due to drug overdose by education at ages 25+ and at ages 30–60, 1992–2011

		Ages 25+		Ages 30–60	
Period	**Education**	**Total Population**	**Non-Hispanic Whites**	**Total Population**	**Non-Hispanic Whites**
A. Males					
1992–1996	LHS	0.24	0.24	0.11	0.11
	HS	0.19	0.18	0.07	0.07
	SC	0.16	0.16	0.06	0.06
	COL	0.11	0.11	0.03	0.03
1997–2001	LHS	0.27	0.27	0.12	0.14
	HS	0.23	0.22	0.09	0.08
	SC	0.20	0.20	0.06	0.06
	COL	0.13	0.13	0.03	0.03
2002–2006	LHS	0.35	0.46	0.15	0.19
	HS	0.32	0.32	0.11	0.11
	SC	0.27	0.28	0.10	0.10
	COL	0.17	0.18	0.04	0.05
2007–2011	LHS	0.46	0.79	0.18	0.28
	HS	0.43	0.50	0.14	0.17
	SC	0.35	0.41	0.11	0.12
	COL	0.18	0.17	0.04	0.04
B. Females					
1992–1996	LHS	0.16	0.18	0.06	0.07
	HS	0.12	0.12	0.03	0.03
	SC	0.12	0.12	0.03	0.04
	COL	0.10	0.10	0.02	0.02
1997–2001	LHS	0.19	0.22	0.07	0.09
	HS	0.15	0.16	0.04	0.04
	SC	0.14	0.14	0.04	0.04
	COL	0.11	0.12	0.02	0.02
2002–2006	LHS	0.31	0.46	0.11	0.17
	HS	0.25	0.27	0.08	0.09
	SC	0.22	0.25	0.06	0.06
	COL	0.12	0.13	0.02	0.03
2007–2011	LHS	0.44	0.75	0.16	0.27
	HS	0.34	0.38	0.10	0.11
	SC	0.30	0.32	0.08	0.08
	COL	0.16	0.17	0.03	0.03

Note: Estimates are based on data from the CDC/NCHS Multiple Cause-of-Death files and the National Health Interview Survey (NHIS). LHS=Less than high school, HS=High school, SC=Some college, COL=College or more

Table 2

Educational gradients in life expectancy and percent of the gradient due to drug overdose, 1992–2011

		Educational Gradient[a] in Life Expectancy at Age 25				Educational Gradient[a] in Years of Life Lived, Ages 30–60			
		Total Population		Non-Hispanic Whites		Total Population		Non-Hispanic Whites	
Period	Education	Years	% due to drug overdose	Years	% due to drug overdose	Years	% due to drug overdose	Years	% due to drug overdose
A. Males									
1992–1996	LHS	8.55	1.5	8.46	1.5	1.53	5.3	1.40	5.8
	HS	4.55	1.7	4.38	1.6	0.73	6.1	0.66	6.4
	SC	3.63	1.4	3.58	1.3	0.57	5.7	0.49	6.4
1997–2001	LHS	8.11	1.7	8.06	1.7	1.29	7.2	1.26	8.4
	HS	4.85	2.1	4.46	2.1	0.73	7.8	0.61	8.6
	SC	4.02	1.7	3.65	1.8	0.45	7.5	0.38	8.1
2002–2006	LHS	8.68	2.1	9.55	2.9	1.15	9.1	1.30	11.1
	HS	5.10	2.9	4.59	3.0	0.59	10.9	0.52	13.2
	SC	3.94	2.4	3.66	2.7	0.51	10.3	0.45	12.1
2007–2011	LHS	10.46	2.7	11.92	5.2	1.24	10.7	1.56	15.4
	HS	6.13	4.0	6.10	5.4	0.77	13.3	0.77	15.8
	SC	4.67	3.6	4.73	5.0	0.52	12.7	0.54	14.4
B. Females									
1992–1996	LHS	7.05	0.9	7.20	1.1	0.89	4.6	0.81	5.6
	HS	2.64	0.5	2.52	0.5	0.26	4.9	0.18	6.0
	SC	1.67	1.0	1.66	1.2	0.21	6.1	0.17	8.1
1997–2001	LHS	7.28	1.2	7.32	1.4	0.84	6.3	0.86	8.0
	HS	3.32	1.3	3.00	1.4	0.37	6.4	0.28	7.5
	SC	1.91	1.6	1.62	1.6	0.23	7.3	0.15	10.0
2002–2006	LHS	9.44	2.0	10.78	3.1	0.91	9.9	1.02	13.8
	HS	4.45	2.9	4.47	3.2	0.49	10.8	0.46	13.7
	SC	2.77	3.5	2.77	4.3	0.26	12.4	0.21	16.6
2007–2011	LHS	9.53	3.0	11.47	5.1	0.96	12.9	1.27	19.1
	HS	4.83	3.7	4.52	4.7	0.46	14.2	0.42	17.7
	SC	2.61	5.1	2.31	6.3	0.25	17.4	0.23	21.6

[a]"Gradient" refers to the difference in life expectancy at age 25 (or in years of life lived between ages 30–60) between each education group and those with a college degree or more.

Note: Estimates are based on data from the CDC/NCHS Multiple Cause-of-Death files and the National Health Interview Survey (NHIS). LHS=Less than high school, HS=High school, SC=Some college.

Table 3

Change in educational gradients in life expectancy and percent of the change due to drug overdose, 1992–2011

		Educational Gradient[a] in Life Expectancy at Age 25				Educational Gradient[a] in Years of Life Lived, Ages 30–60			
		Total Population		Non-Hispanic Whites		Total Population		Non-Hispanic Whites	
Period	Education	Δ Gradient	% Δ due to drug overdose	Δ Gradient	% Δ due to drug overdose	Δ Gradient	% Δ due to drug overdose	Δ Gradient	% Δ due to drug overdose
A. Males									
1992–1996	LHS	1.91	8.0	3.45	14.2	−0.29	-	0.16	99.1
	HS	1.57	10.8	1.72	15.4	0.04	100.0	0.11	71.9
	SC	1.04	11.4	1.14	16.7	−0.06	-	0.05	94.1
1997–2001	LHS	2.35	6.0	3.85	12.5	−0.05	-	0.30	45.1
	HS	1.28	11.4	1.64	14.7	0.04	100.0	0.16	42.2
	SC	0.65	15.6	1.08	16.1	0.07	44.5	0.16	29.6
2002–2006	LHS	1.78	5.6	2.37	14.5	0.09	31.4	0.26	37.0
	HS	1.03	9.7	1.50	12.8	0.18	21.3	0.25	21.1
	SC	0.73	10.1	1.07	13.0	0.01	100.0	0.09	25.7
B. Females									
1992–1996	LHS	2.47	8.9	4.27	11.9	0.07	100.0	0.47	42.3
	HS	2.20	7.6	2.00	10.0	0.20	26.1	0.24	26.4
	SC	0.94	12.4	0.65	19.3	0.04	77.6	0.06	62.2
1997–2001	LHS	2.25	8.6	4.14	11.5	0.12	58.3	0.41	42.0
	HS	1.51	9.0	1.52	11.2	0.09	46.5	0.14	38.2
	SC	0.70	14.7	0.68	17.3	0.03	100.0	0.08	42.4
2002–2006	LHS	0.09	100.0	0.69	35.7	0.05	65.6	0.26	39.8
	HS	0.38	13.7	0.06	100.0	−0.03	-	−0.04	-
	SC	−0.16	-	−0.46	-	−0.01	-	0.02	63.7

[a]"Gradient" refers to the difference in life expectancy at age 25 (or in years of life lived between ages 30–60) between each education group and those with a college degree or more. "Δ Gradient" refers to the change in the gradient between each period and the most recent period, 2007–2011.

Note: Estimates are based on data from the CDC/NCHS Multiple Cause-of-Death files and the National Health Interview Survey (NHIS). Percent contributions in cases where very small changes in life expectancy gradients have occurred (e.g., <0.10 years) should be interpreted with caution. LHS=Less than high school, HS=High school, SC=Some college.

- indicates that the gradient decreased over time, and that the decrease would have been even larger in the absence of drug overdose

Appendix Table 1

Life expectancy at age 25 and years of life lived between ages 30 and 60 in the absence of drug overdose, three variants

		Life Expectancy at Age 25			Years of Life Lived, Ages 30–60		
Period	**Education**	**All States[a]**	**≥90% Complete[b]**	**34 States[c]**	**All States[a]**	**≥90% Complete[b]**	**34 States[c]**
A. Males							
1992–1996	LHS	46.40	46.40	46.41	27.86	27.86	27.86
	HS	50.35	50.35	50.35	28.62	28.62	28.62
	SC	51.24	51.24	51.24	28.77	28.77	28.77
	COL	54.82	54.82	54.82	29.31	29.31	29.31
1997–2001	LHS	48.31	48.31	48.31	28.31	28.31	28.31
	HS	51.53	51.53	51.53	28.83	28.83	28.83
	SC	52.32	52.32	52.32	29.09	29.09	29.09
	COL	56.28	56.28	56.28	29.50	29.50	29.50
2002–2006	LHS	48.71	48.71	48.71	28.41	28.41	28.41
	HS	52.25	52.25	52.26	28.93	28.93	28.93
	SC	53.35	53.36	53.36	29.00	29.00	29.00
	COL	57.20	57.20	57.20	29.45	29.45	29.45
2007–2011	LHS	48.61	48.60	48.60	28.43	28.43	28.42
	HS	52.91	52.90	52.91	28.87	28.87	28.87
	SC	54.29	54.28	54.28	29.08	29.08	29.08
	COL	58.79	58.79	58.79	29.54	29.53	29.53
B. Females							
1992–1996	LHS	52.99	52.99	53.00	28.70	28.70	28.70
	HS	57.36	57.36	57.36	29.31	29.31	29.31
	SC	58.33	58.33	58.34	29.35	29.35	29.35
	COL	59.98	59.99	59.99	29.55	29.55	29.55
1997–2001	LHS	53.41	53.41	53.42	28.86	28.86	28.86
	HS	57.32	57.32	57.33	29.30	29.30	29.30
	SC	58.72	58.73	58.73	29.44	29.44	29.44
	COL	60.60	60.60	60.60	29.65	29.65	29.65
2002–2006	LHS	53.08	53.08	53.08	28.87	28.87	28.87
	HS	58.01	58.01	58.01	29.25	29.25	29.25
	SC	59.66	59.66	59.67	29.46	29.46	29.46
	COL	62.33	62.33	62.33	29.68	29.68	29.69
2007–2011	LHS	53.69	53.68	53.68	28.83	28.82	28.82
	HS	58.28	58.27	58.28	29.27	29.27	29.27
	SC	60.46	60.46	60.47	29.46	29.45	29.46
	COL	62.93	62.93	62.94	29.66	29.66	29.66

Note: Estimates are based on data from the CDC/NCHS Multiple Cause-of-Death files and the National Health Interview Survey (NHIS).

LHS=Less than high school, HS=High school, SC=Some college, COL=College or more.

[a]Uses MCD data from all states with any reporting of education on death certificates

[b]Uses MCD data from states with at least 90% completeness of education reporting

[c]Uses MCD data from the 34 states that had at least 90% completeness of education reporting in 1992

Appendix Table 2

Drug overdose death as a percentage of total deaths by age, education, and sex, select years in 1992–2011

		Total Population				Non-Hispanic Whites			
Year	**Age**	**LHS**	**HS**	**SC**	**COL**	**LHS**	**HS**	**SC**	**COL**
A. Males									
	25–29	5.20	4.48	3.36	2.41	5.82	5.07	4.23	2.77
	30–34	6.36	5.19	4.40	3.22	6.95	5.80	5.04	3.64
	35–39	5.72	5.94	5.59	3.14	6.34	6.31	6.07	3.39
	40–44	3.49	3.91	3.59	2.40	3.71	3.88	3.51	2.49
	45–49	1.64	1.39	1.38	1.13	1.36	1.31	1.42	1.16
	50–54	0.52	0.60	0.51	0.98	0.41	0.53	0.46	1.03
1992	55–59	0.21	0.26	0.22	0.32	0.19	0.25	0.17	0.35
	60–64	0.11	0.12	0.14	0.22	0.12	0.12	0.15	0.23
	65–69	0.07	0.08	0.07	0.15	0.07	0.08	0.07	0.17
	70–74	0.03	0.04	0.09	0.11	0.03	0.04	0.09	0.12
	75–79	0.04	0.04	0.02	0.13	0.03	0.04	0.02	0.14
	80–84	0.04	0.03	0.07	0.07	0.04	0.03	0.07	0.08
	85+	0.04	0.04	0.02	0.04	0.04	0.04	0.02	0.04
	25–29	14.67	20.13	20.12	14.61	26.17	27.62	26.18	17.86
	30–34	15.08	18.13	19.13	12.28	24.95	24.31	24.05	15.49
	35–39	12.93	14.79	13.25	10.67	20.41	19.21	16.69	13.11
	40–44	11.05	11.33	9.33	7.00	14.63	13.61	11.05	8.27
	45–49	7.56	7.75	7.30	5.22	9.87	9.09	8.20	5.79
	50–54	4.53	4.64	4.37	3.39	5.51	5.08	4.91	3.70
2010	55–59	2.08	2.52	2.38	2.00	2.40	2.70	2.50	2.19
	60–64	0.83	1.04	0.85	0.94	0.87	1.03	0.85	0.95
	65–69	0.22	0.28	0.23	0.31	0.20	0.24	0.23	0.32
	70–74	0.12	0.12	0.13	0.15	0.10	0.11	0.14	0.15
	75–79	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
	80–84	0.03	0.05	0.08	0.07	0.03	0.05	0.08	0.07
	85+	0.02	0.04	0.04	0.04	0.02	0.04	0.05	0.04
	25–29	16.11	20.70	23.00	15.62	28.52	28.33	30.04	19.12
	30–34	16.59	20.13	20.60	14.34	26.79	26.26	26.53	17.52
	35–39	14.88	15.80	13.80	11.79	22.66	19.75	17.41	13.94
	40–44	12.09	11.40	10.57	8.10	16.47	13.86	12.64	9.12
	45–49	7.76	8.78	6.94	5.26	9.79	10.16	7.98	5.90
2011	50–54	4.98	4.82	4.73	3.76	6.14	5.36	5.27	4.16
	55–59	2.40	2.69	2.62	2.08	2.85	2.72	2.77	2.31
	60–64	0.83	1.00	1.01	0.99	0.87	0.97	1.01	0.99
	65–69	0.30	0.34	0.28	0.44	0.30	0.34	0.26	0.46
	70–74	0.11	0.12	0.13	0.21	0.13	0.12	0.14	0.21
	75–79	0.05	0.08	0.07	0.11	0.06	0.07	0.08	0.12

Year	Age	Total Population LHS	HS	SC	COL	Non-Hispanic Whites LHS	HS	SC	COL
	80–84	0.02	0.04	0.06	0.08	0.02	0.04	0.06	0.09
	85+	0.03	0.02	0.02	0.04	0.03	0.03	0.02	0.04
B. Females									
	25–29	5.46	5.04	3.58	4.35	5.61	5.88	4.35	5.04
	30–34	7.89	5.39	5.21	4.48	10.17	6.77	6.39	4.54
	35–39	4.77	4.79	4.99	3.58	6.34	5.57	6.02	3.85
	40–44	2.93	2.79	3.27	3.04	3.35	3.23	4.09	3.37
	45–49	1.17	1.87	1.89	2.21	1.57	2.04	2.23	2.64
	50–54	0.70	0.92	1.01	1.42	0.92	1.00	1.26	1.73
1992	55–59	0.32	0.48	0.49	0.76	0.43	0.58	0.56	0.85
	60–64	0.19	0.28	0.35	0.59	0.25	0.30	0.38	0.70
	65–69	0.14	0.16	0.27	0.33	0.12	0.17	0.26	0.36
	70–74	0.06	0.10	0.19	0.20	0.07	0.10	0.21	0.22
	75–79	0.06	0.09	0.09	0.10	0.06	0.09	0.10	0.11
	80–84	0.04	0.07	0.06	0.09	0.04	0.07	0.05	0.10
	85+	0.03	0.04	0.03	0.02	0.03	0.05	0.02	0.02
	25–29	20.37	20.52	20.03	12.79	33.33	27.33	26.65	16.54
	30–34	19.10	18.95	19.92	9.86	29.78	25.42	25.71	13.11
	35–39	16.39	15.64	16.30	10.37	26.29	21.04	21.45	13.45
	40–44	12.74	11.97	12.43	7.96	19.80	15.04	15.39	9.89
	45–49	8.79	9.56	9.29	5.68	12.15	11.83	11.72	6.68
	50–54	5.10	6.10	6.23	4.24	6.54	7.25	7.72	5.23
2010	55–59	2.67	2.85	3.58	2.92	3.49	3.32	4.18	3.45
	60–64	0.86	1.09	1.50	1.39	1.14	1.23	1.75	1.62
	65–69	0.33	0.40	0.69	0.57	0.40	0.45	0.80	0.63
	70–74	0.15	0.19	0.21	0.23	0.18	0.20	0.25	0.24
	75–79	0.07	0.11	0.13	0.17	0.08	0.12	0.14	0.18
	80–84	0.05	0.06	0.06	0.08	0.06	0.06	0.07	0.09
	85+	0.02	0.04	0.04	0.05	0.02	0.04	0.04	0.05
	25–29	20.85	20.83	20.70	11.67	29.71	28.14	28.16	14.29
	30–34	21.09	19.97	21.62	10.60	30.29	26.93	28.74	12.69
	35–39	17.08	16.34	17.53	9.74	25.39	22.18	23.61	12.06
	40–44	14.97	12.92	13.16	9.60	21.34	16.24	16.53	11.25
	45–49	9.91	9.86	9.42	6.45	13.80	12.20	11.95	7.77
2011	50–54	5.86	6.18	6.19	5.19	7.79	7.36	7.58	6.18
	55–59	2.27	3.31	3.54	3.18	2.89	3.84	4.06	3.64
	60–64	0.84	1.25	1.41	1.31	1.00	1.36	1.66	1.46
	65–69	0.35	0.46	0.59	0.75	0.44	0.51	0.62	0.82
	70–74	0.15	0.19	0.26	0.34	0.17	0.21	0.30	0.38
	75–79	0.05	0.10	0.10	0.13	0.06	0.10	0.10	0.14

Year	Age	Total Population LHS	Total Population HS	Total Population SC	Total Population COL	Non-Hispanic Whites LHS	Non-Hispanic Whites HS	Non-Hispanic Whites SC	Non-Hispanic Whites COL
	80–84	0.05	0.06	0.10	0.14	0.06	0.06	0.11	0.15
	85+	0.03	0.03	0.03	0.04	0.03	0.03	0.04	0.04

Note: Based on data from the CDC/NCHS Multiple Cause-of-Death files. LHS=Less than high school, HS=High school, SC=Some college, COL=College or more.