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Abstract

Educational attainment may be an indicator of disparities in the ongoing opioid-overdose crisis. To understand the association between educational attainment and fatal opioid overdose, death records in the mortality files published by the Centers for Disease Control and Prevention (CDC) from 2010 - 2019 were analyzed. Proportionate mortality due to opioid overdose, PMOD, was used, as age-adjusted death rates suffer dual data-source errors caused by differences in educational data reported in death records and in population surveys. From 2013 to 2019, PMOD increased by 120% for the “less-than-high-school-diploma” (<HS) education group, whereas the increase was 60% and 30% for groups with bachelor’s and graduate-level educations, respectively. Educational gradient was observed for both males and females, with PMOD for males higher than females. From 2013 to 2019, males and females with <HS education experienced 142% and 85% increases in PMOD, respectively, compared with the 94% and 26% increases for males and females, respectively, with BS education. The PMOD increase was primarily driven by synthetic opioids (ICD-10 code T40.4). From 2013 to 2019, for males with <HS education, PMOD related to T40.4 opioids increased by 19-fold, whereas the increase was more than 100-fold for adult Black males with <HS education. These results suggest that the impact of lower educational attainment may be getting worse and furthering inequities in health. Responses to the opioid-overdose epidemic should consider the large educational gradient. Extra attention to the most vulnerable groups is necessary.

Introduction

Educational attainment is one of the most important socioeconomic factors that affect mortality (Hummer, 2013). Lower educational attainment is associated with shortened life expectancy (Rogers et al., 2010). Sasson reported the trends in both life expectancy and deviation of age at death by educational attainment (Sasson, 2016). For deaths related to substance use, Ho analyzed the contribution of drug overdose to educational gradients in life expectancy for the 1991-2011 timeframe (Ho, 2017). Since then, drug overdose deaths in the US have increased dramatically. Especially in recent years since 2013, there has been an exponential increase in opioid-related overdose deaths (Hedegaard et al., 2020). In this study, our objective is to examine the most recent data to understand the association between educational attainment and opioid overdose death rate.

Methods

Data were collected from the mortality multiple cause files published on the Vital Statistics Online Data Portal by the National Center for Health Statistics (NCHS), Centers for Disease Control and Prevention (CDC) (CDC National Center for Health Statistics: Vital Statistics Online Data Portal). One mortality multiple cause file is published each year, which includes data for each of the deaths occurring in the 50 states, the District of Columbia and US territories

including Guam, Puerto Rico, Virgin Islands, American Samoa, and the Commonwealth of the Northern Marianas. Demographic information pursuant to the death is based on information supplied by an informant, and the medical cause of death is certified by a physician, medical examiner, or coroner (CDC National Vital Statistics System: Public Use Data File Documentation). A code based on the International Classification of Diseases version 10 (ICD-10) is listed for each contributory cause of death. Overdose deaths are classified using underlying cause-of-death codes X40-44 (unintentional), X60-64 (suicide), X85 (homicide), or Y10-14 (undetermined). Among drug overdose deaths, the types of opioid involved were indicated by the following ICD-10 codes listed in the multiple cause-of-death section: opioids (T40.0, T40.1, T40.2, T40.3, T40.4); heroin, an illicit opioid synthesized from morphine (T40.1); natural (e.g. morphine and codeine) and semisynthetic opioids (e.g. drugs such as hydrocodone, oxycodone, oxymorphone and hydromorphone) (T40.2); methadone (T40.3); other synthetic narcotics, such as fentanyl and tramadol, either legally prescribed or illicitly manufactured (T40.4). The categories of drugs were not mutually exclusive: deaths with more than one codes listed were included for each drug type.

Although NCHS death record files are considered 100 percent complete and serve as one of the most comprehensive records of all U.S. deaths, the accuracy of the cause-of-death are influenced by a number of factors (Becker, 2021), such as changes in ICD, training of the medical certifiers, advances in diagnostic and forensic technology that can change how causes of deaths are identified and coded.

To avoid potential bias toward lower educational attainment among younger populations, only adults 25 years or older were included. For characterization of death rates, proportionate mortality was selected as the normalized death-rate metric rather than the commonly used age-adjusted death rate. The motivation was that in educational gradient analysis, age-adjusted death rates (AADR) are subject to a dual data-source error caused by systematic differences in educational attainment data reported in death records and in population surveys (Hendi, 2017). For example, one prior study reported that 38% of decedents with high-school graduation listed on their death records in 1989 had previously self-reported having <HS educational attainment (Sorlie, 1996). That number changed to 23% for 1992 – 1998 (Rostron, 2010). Since the calculation of AADR requires the division of the number of deaths by the population count, the discrepancy in the categorization of education attainment for the numerator (death data) and denominator (population data) results in the so-called dual data-source error in AADR.

Proportionate mortality avoids dual data-source error as it is calculated using data from one source. In this study, proportionate mortality due to opioid overdose, PMOD, is used. For any specific population group, the PMOD value equals to the number of opioid overdose deaths in this group divided by the total number of deaths in this group, using % as the unit for the result. Here both the numerator and denominator values use death records as the data source, eliminating errors associated with discrepancies between different data sources. As a comparison, the U.S. deaths in 2018 related to opioid overdose are plotted against educational attainment using the AADR metric (Fig. 1a) and the PMOD metric (Fig. 1b). The trend in opioid related AADR from “high-school diploma” education (HS) to “some college credit but no degrees” education (no-deg) and the reversal in trend from no-deg to “associated degree” (A.A.) education are different from the PMOD trend, and the difference could be related to differences in educational data on death records and in population surveys.

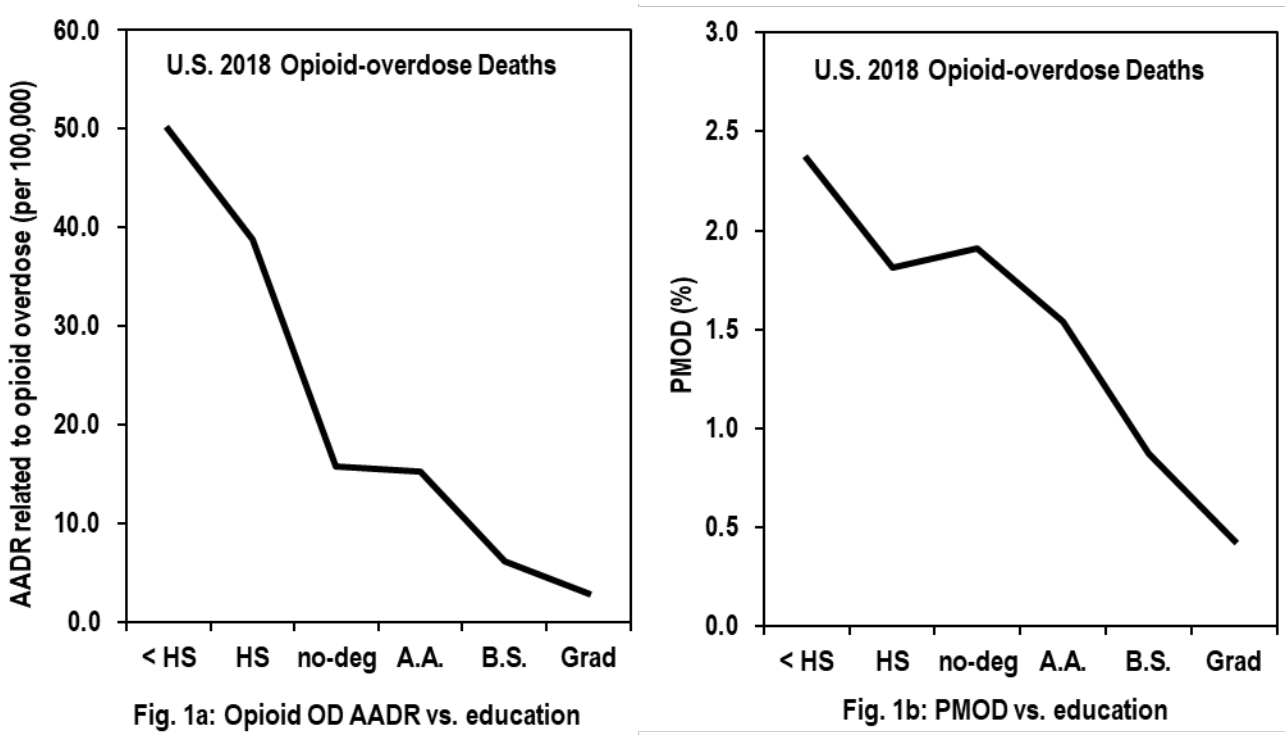

Figure 1: (a) variation of the U.S. 2018 age-adjusted death rate (AADR) related to opioid overdose vs. educational attainment*; (b) variation of the U.S. 2018 proportionate mortality related to opioid overdose (PMOD) vs. educational attainment.

*Educational attainment:

<HS: less than high-school diploma

HS: high-school diploma (or equivalent)

no-deg: some college credit but no degrees

AA: associate degree

BS: bachelor's degree

Grad: graduate-level education

Results

Large disparities were observed in opioid overdose deaths among populations with different educational attainment. PMOD decreased as educational attainment increased (Fig. 2a). Similar trends were observed for each of the years from 2010 to 2019. While the national rates of educational status have improved steadily from 2010 to 2019, with increasing percentage of the population having bachelor's or graduate-level educations and decreasing percentage of the population having <HS education (Fig. 2b), the disparities in PMOD among groups with different educational attainment grew larger. From 2013 to 2019, population groups with lower educational attainment experienced much larger increases in PMOD (Fig. 3a). In this time frame, PMOD increased by 120% for the group with <HS education whereas the increase was 60% and 30% respectively for the groups with BS and Grad education. The increases in PMOD

were primarily driven by increases in overdose deaths related to T40.4 opioids (synthetic opioids other than methadone, such as fentanyl and tramadol, either legally prescribed or illicitly manufactured) (Fig. 3b). The association of higher PMOD with lower educational attainment was observed in both male and female populations, although PMOD among males was higher than among females. From 2013 to 2019, adult male and female populations with <HS education experienced 142% and 85% increases in PMOD respectively, compared with the 94% and 26% increases respectively for the male and female populations with BS education (Fig. 4a). The differences were even larger in PMOD related to T40.4 opioids. From 2013 to 2019, for the adult male group with <HS educational attainment, PMOD related to T40.4 opioids increased by 19-fold (Fig. 4b), with 2.7% of all deaths in 2019 being related to T40.4 opioids overdose. As one of the most vulnerable groups, the adult Black male population with <HS educational attainment suffered a 100-fold increase in PMOD related to T40.4 opioids (Fig. 5a), with 3.4% of all deaths in 2019 being related to T40.4 opioids overdose. Furthermore, compared with the White population, the Black population had much smaller difference in PMOD between groups with <HS education and with HS education (Fig. 5b), consistent with minorities' diminishing returns observed in multiple studies (Assari, 2018; Farmer et al, 2005; Assari et al, 2021).

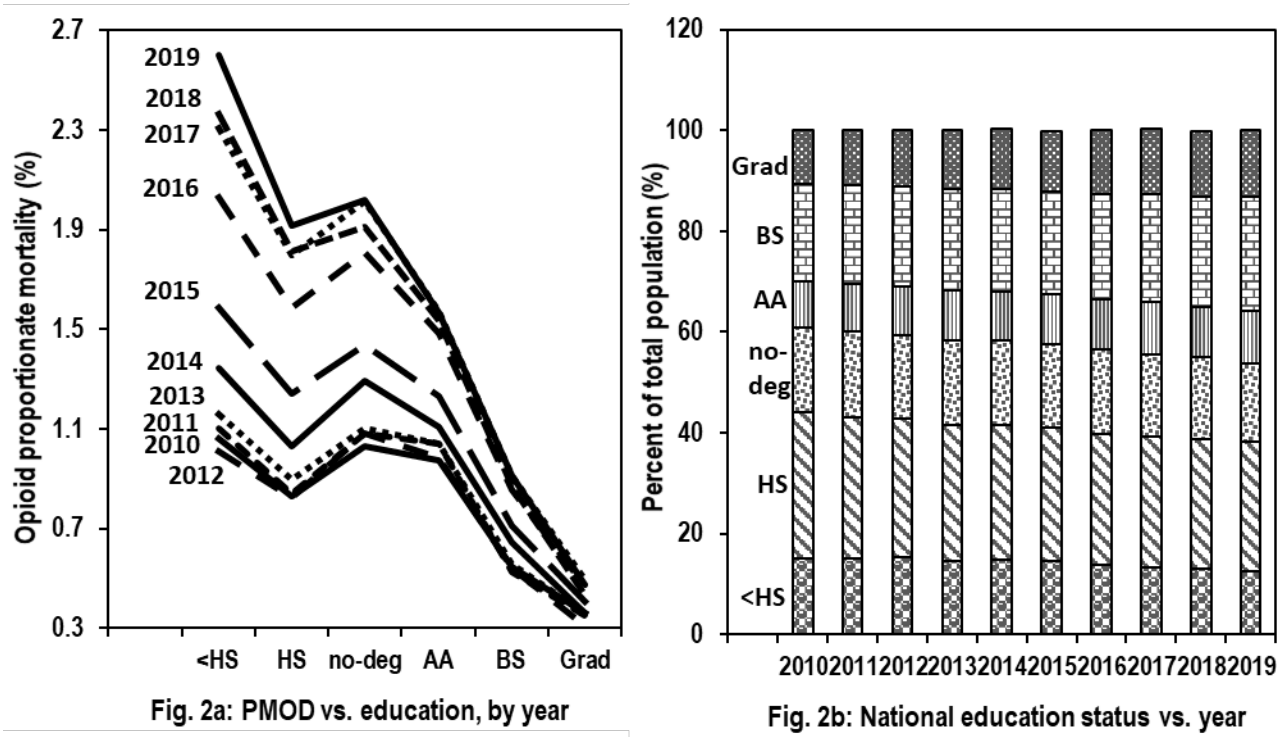

Figure 2: (a) variation of U.S. proportionate mortality related to opioid overdose (PMOD) with educational attainment*, by year; (b) variation of U.S. educational attainment with year.

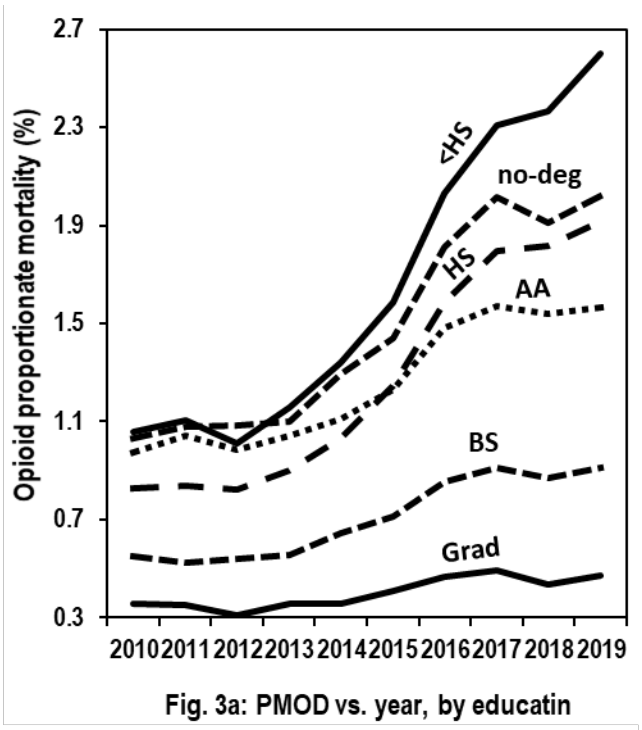

Fig. 3a: PMOD vs. year, by educatin

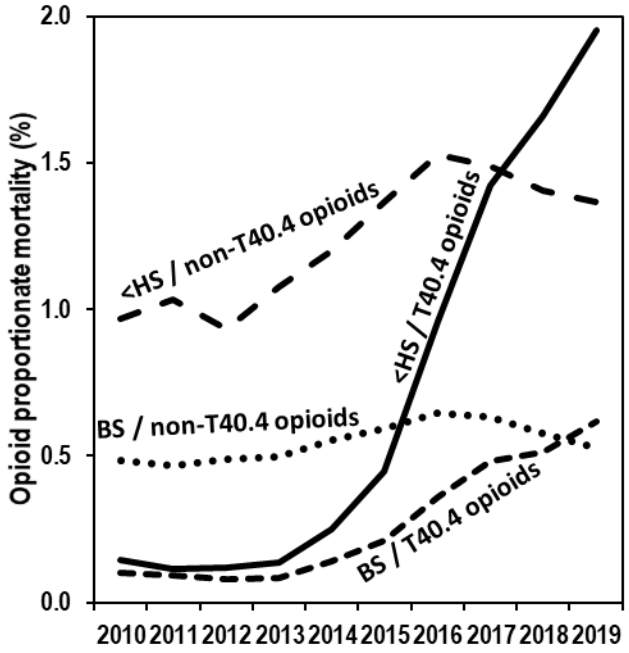

Fig. 3b: PMOD vs yr, by education/opioid

Figure 3: (a) Variation of U.S. proportionate mortality due to opioid (PMOD) with year, by educational attainment; (b) Variation of U.S. PMOD with year, by educational attainment / type of opioid involved: T40.4 (synthetic opioids other than methadone) and non-T40.4 opioids.

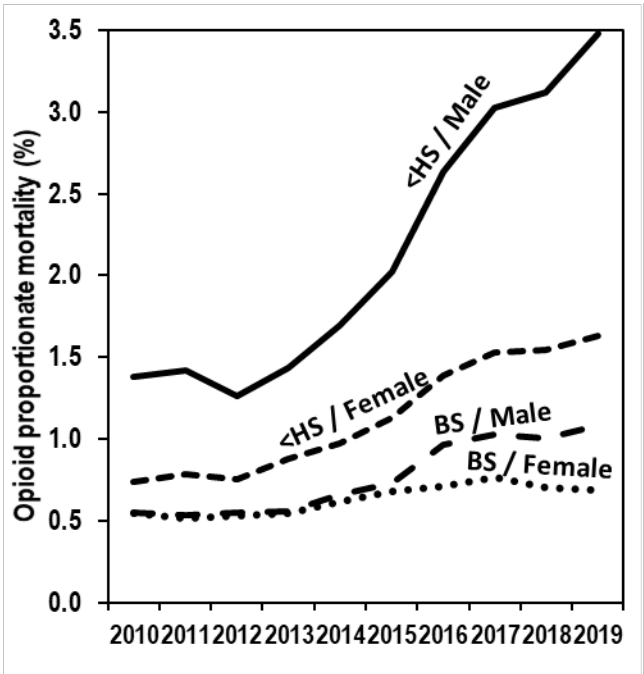

Fig. 4a: PMOD vs. yr, by education / sex

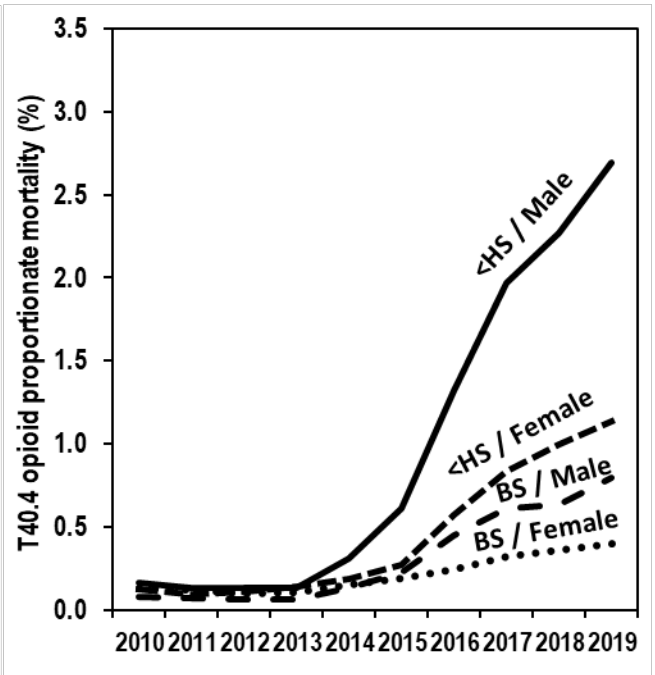

Fig. 4b: T40.4 PMOD vs yr, by education/sex

Figure 4: (a) variation of U.S. proportionate mortality due to opioids with year, by education / sex; (b) variation of U.S. proportionate mortality due to T40.4 opioids (synthetic opioids other than methadone) with year, by education / sex.

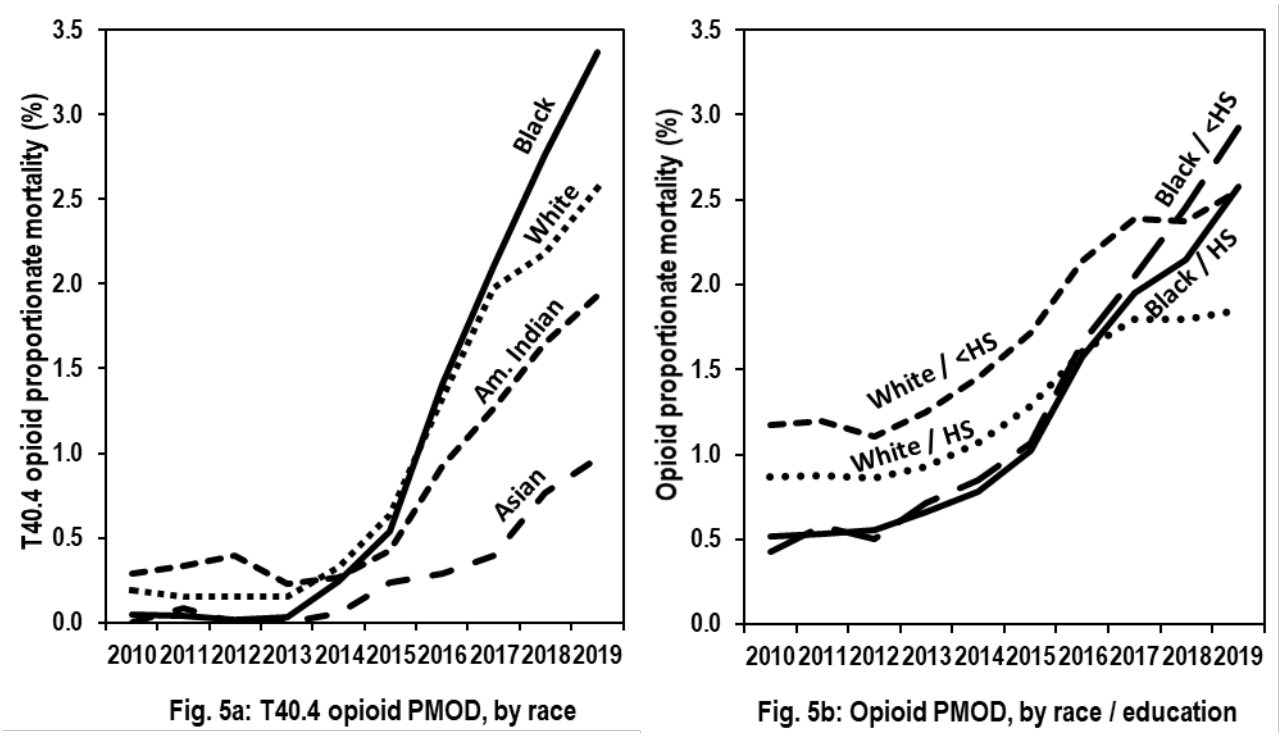

Figure 5: (a) variation of U.S. proportionate mortality due to T40.4 opioids (synthetic opioids other than methadone) with year, for adult males, by race; (b) variation of U.S. proportionate mortality due to opioids with year, for White and Black populations with <HS and HS educational attainment.

Discussion

Characterization of overdose death rates using the PMOD metric revealed large disparities in opioid overdose deaths among groups with different educational attainment. As shown in Fig. 1a, large differences in PMOD were observed between populations with lower and higher educational attainments. The magnitude of the difference has increased from 2010 to 2019, driven by increasing PMOD in groups with lower educations. These results suggest that the impact of lower educational attainment, and hence lower socioeconomic status, may be getting worse and furthering inequities in health. Additionally, the decreasing trend of PMOD with increasing education in Fig. 1a reversed when the educational attainment increased from “high-school diploma” (HS) to “some college credits but no degrees” (no-deg). The reversal was observed consistently for all years. This is consistent with expectations: premature termination of college education represents a significant setback that may lead to more stress or depression and higher likelihood of substance abuse; vice versa, substance abuse may lead to premature termination of college education. Therefore, association of higher PMOD with premature termination of education is expected. It is worth noting that this association was not revealed

when the same set of data was analyzed using the age-adjusted death-rate metric to characterize overdose death rates (Fig. 1a).

Among populations with different socioeconomic status, adult Black males with <HS educational attainment was one of the most vulnerable groups. From 2013 to 2019, for the overall adult population, PMOD related to all opioids increased by 90%, from 0.9% in 2013 to 1.7% in 2019, and PMOD related to T40.4 opioids increased by 9-fold, from 0.11% in 2013 to 1.2% in 2019. During the same time period, for the adult Black population with <HS educational attainment, PMOD related to all opioids increased by 260%, from 0.6% in 2013 to 2.2% in 2019, and PMOD related to T40.4 opioids increased by more than 100-fold, from 0.03% in 2013 to 3.4% in 2019. The much larger increase of PMOD among the Black population could in part be associated with racial inequity in opioid analgesia. Numerous studies have shown that Black patients are less likely to receive opioids, or receive lower doses of opioids, than white patients, including children with appendicitis (Goyal et al, 2015), back pain (Mills et al, 2011), cesarean delivery (Johnson et al., 2019), and treatment for opioid use disorder (Rosenthal et al., 2021). It is possible that non-treatment or undertreatment of pain or opioid use disorder may result in Black using unauthorized opioids, which may include illicitly manufactured opioids or be contaminated by fentanyl or its highly potent analogues. Similarly, the reduction of PMOD due to non-T40.4 and T40.4 opioids could also be driven by changes of government policies to limit and restrict access to prescription opioid analgesics (Raji et al, 2018).

The findings in this report are subject to several limitations. First, PMOD can vary with variations in deaths from different causes (Morano et al., 2018). Variations from other causes lead to changes in the total number of deaths, which affect the percentage value of PMOD. Second, PMOD only reflects the severity of opioid overdose deaths relative to total deaths but does not reflect the absolute number of deaths. Third, protocols for forensic toxicology testing can vary with time (Mattson et al, 2021). Postmortem toxicology of synthetic opioids has improved in the past 5 years (Concheiro et al, 2018). As a result, some of the observed increases in overdose deaths could be attributed to more comprehensive testing. Fourth, a certain percentage of death certificates did not list the specific types of drugs involved. The percentage varied from year to year, for example, 15% of drug overdose death certificates in 2016 and 12% in 2017 did not list the specific types of drugs involved (Scholl et al., 2019). Hence some of the observed increases in overdose deaths could be attributed to increased reporting of specific drugs.

Conclusion

For educational gradient analysis of overdose deaths, using the proportionate mortality metric can provide additional insights to supplement conclusions drawn using the standard age-adjusted death-rate metric. Populations with lower educational attainments suffered much higher proportionate mortality related to opioid overdose. The differences have grown even larger since 2013. In response to the opioid overdose epidemic, when allocating limited healthcare resources and planning prevention efforts, the large disparities in opioid overdose deaths among populations with different educational attainments need to be considered. Extra attention to the most vulnerable groups is necessary.

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