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Patterns and trends in accidental poisoning death rates in the US, 1979–2014

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ABSTRACT

Objectives. The purpose of this study was to examine US accidental poisoning death rates by demographic and geographic factors from 1979 to 2014, including High Intensity Drug Trafficking Areas.

Methods. Crude and age-adjusted death rates were formed for age group, race, sex, and county for accidental poisonings (ICD 9th revision: E850–E869; ICD 10th revision: X40–X49) from 1979 to 2014 using the Mortality and Population Data System housed at the University of Pittsburgh. Rate ratios were calculated comparing rates from 2014 to 1979, overall, by sex, age group, race, and county. Joinpoint regression detected changes in trends and calculated the average annual percentage change (AAPC) as a summary measure of trend.

Results. Drug poisoning mortality rates have risen an average of 6% per year since 1979. Increases are occurring in all ages 15+, and in all race–sex groups. HIDTA counties with the highest mortality rates were in Appalachia and New Mexico. Many of the HIDTA border counties had lower rates of mortality.

Conclusions. The drug poisoning mortality epidemic is continuing to grow. While HIDTA resources are appropriately targeted at many areas in the US most affected, rates are also rapidly rising in some non-HIDTA areas.

Poisoning deaths have been increasing in the US since the early 1990s (Warner et al., 2011; Chen et al., 2015). In 2008, poisoning deaths exceeded deaths due to motor vehicle accidents for the first time (Warner et al., 2011) and 89% of these were due to drug poisonings. The majority of poisoning deaths were accidental, or unintentional, from both illicit and prescription drugs. A previous examination of accidental poisoning death rates from 1999 to 2004 found higher rates in males, American Indian/Alaska Natives, 35–44 and 45–54 year olds and in the South and West (Paulozzi and Annest, 2007). However, more recent studies have found that overall death rates are rising for middle-aged non-Hispanic Whites (Case and Deaton, 2015) and for White females ages 15 to 64 (Astone et al., 2015). Astone et al. (2015) attribute some of the rising mortality rates in White females to increases in accidental poisoning deaths, while Case and Deaton identified a combination of increasing poisoning, suicide and cirrhosis death rates for the overall rise in 45–54 year old non-Hispanic White mortality (Case and Deaton, 2015). The increase in accidental poisonings has been generally thought to be due to increases in the number of prescription opioids made available to Whites (Paulozzi and Annest, 2007). A 2008 examination of opioid prescribing patterns found the highest rates in Appalachia and in southern and western states (McDonald et al., 2012), correlating with recent increases in mortality in these areas. In a 2013 study, Rossen et al. (2013) examined 1999–2009 drug poisoning mortality rates by US region and at the county level. They found that in 1999–2000 only 3% of counties had age-adjusted mortality rates (AAMR) greater than 10/100,000; by 2008–2009, 54% of counties exceeded this rate.

The High Intensity Drug Trafficking Areas program was created by Congress in 1988, consisting of 31 areas in the US with high drug trafficking, with coordinated law enforcement resources dedicated to reducing trafficking and production (Appendix). In 2015, the program was funded to begin a "Heroin Response Strategy" specifically aimed at five areas with high rates of heroin trade: Appalachia, New England, Philadelphia–Camden, New York–New Jersey, and Washington–Baltimore. However, to date, accidental drug poisoning mortality rates have not been examined in High Intensity Drug Trafficking Areas.

The purpose of this study was to update and expand upon earlier studies of accidental poisoning deaths by examining rates by sex, race, age, and county from 1979 to 2014 in the US. This study also examined accidental poisoning mortality patterns in High Intensity Drug Trafficking Areas. These analyses will help to inform public health officials and

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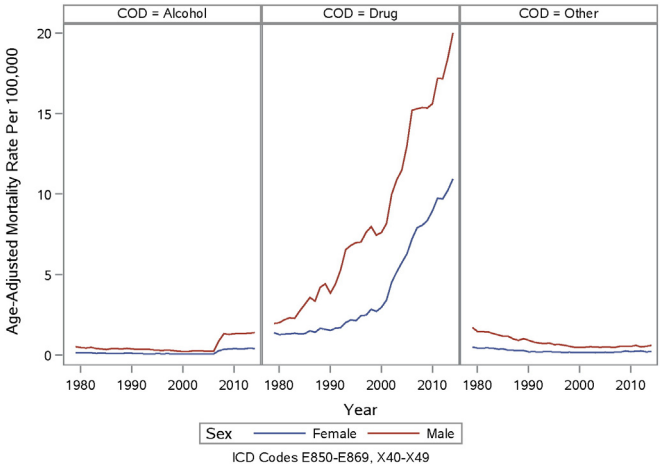

Fig. 1. a–c. US age-adjusted accidental poisoning mortality rates per 100,000, 1979–2014, by sex for type of overdose, ages 15+.

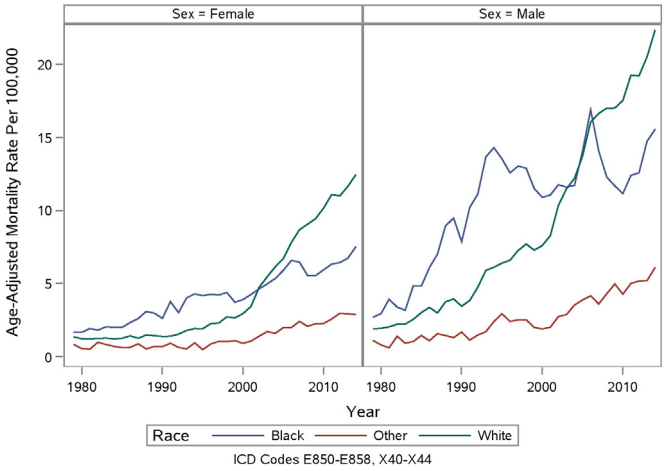

Fig. 2. a and b. US age-adjusted accidental drug poisoning mortality rates for males and females by race, ages 15+.

decision makers, law enforcement, and legislators about areas which may be in need of additional resources to combat epidemic levels of accidental drug poisoning mortality.

1. Methods

The Mortality and Population Data System (MPDS) (Marsh et al., 2004), a comprehensive repository maintained through the University of Pittsburgh, was used to obtain death counts and corresponding populations by age group (15–24, 25–34, 35–44, 45–54, and 65+), race (White, African American, Other), sex, state, and county from 1979 to 2014. The MPDS contains individual demographic and geographic information plus the underlying cause of death code (using International Classification of Diseases codes) for 120 million+ decedents; we focus here on deaths from accidental poisonings (ICD 9th revision: E850–E869; ICD 10th revision: X40–X49). These codes include accidental poisoning deaths from both prescription drugs, such as prescription opioids, and from illicit drugs, such as heroin. In this analysis we were not able to differentiate type of drug involved in the accidental poisoning. We restricted the analyses to age groups 15+ due to the dearth of drug poisoning deaths in ages younger than 15 (approximately 20–30/year).

We grouped causes of death into type of overdose: drugs (ICD 9th revision: E850–E858; ICD 10th revision: X40–X44); alcohol (ICD 9th revision: E860; ICD 10th revision: X45); and other causes of poisoning (ICD 9th revision: E861–E869; ICD 10th revision: X46–X49). To interpret trends in accidental poisoning mortality across ICD 9th and 10th revisions, the comparability ratio adopted by Baggett and Hwang (Baggett et al., 2013) of 1.195 was applied to 9th revision data. Accidental poisoning codes changed dramatically between the 8th and 9th revision ICD versions, as such these analyses were limited to the time period corresponding to ICD 9th and 10th revision.

The epitab csi command in STATA was used to calculate rate ratios for age-specific rates with corresponding 95% confidence intervals, to compare mortality rates over the 1979 to 2014 time period (StataCorp, 2014). The 2000 standard million weights were applied to calculate age-adjusted mortality rates (AAMR) for ages 15+, based on the previously described age groupings. AAMRs were examined graphically over time by type of overdose, sex, and race.

Standard errors for rates were calculated via methods outlined by the CDC for age-specific rates, age-adjusted rates, and comparability ratio adjusted rates (Centers for Disease Control and Prevention, National Center for Health Statistics, 2000). Standard errors are equal to the rate multiplied by the relative standard error (RSE) of the rate divided by 100, where the relative standard error takes on different forms depending on the type of rate (Centers for Disease Control and Prevention, National Center for Health Statistics, 2000). Confidence intervals for standardized rate ratios (SRRs) were calculated as the ratio of AAMRs raised to the power of (1 plus or minus 1.96 / X), where X is $(SRR_{2014} - SRR_{1979}) / \text{sqrt}(SE(SRR_{2014})^2 + SE(SRR_{1979})^2)$.

Trends in accidental drug poisoning AAMRs overall, by race, and by sex; were analyzed using the Joinpoint regression program (Joinpoint Regression Program, 2015). Age-specific mortality rate trends were

Table 1
Numbers, age-adjusted rates per 100,000, standardized rate ratios, and average annual percent change of accidental drug poisoning deaths[a] among persons age 15+ in the US, by selected characteristics.

		1979[c]			2014			SRR	95% CI	AAPC[b]	95% CI
		Deaths	Rate	95% CI	Deaths	Rate	95% CI				
Overall		2475	1.67	(1.60–1.74)	38,675	15.47	(15.31–15.63)	9.26	(9.01–9.52)	6.65	(4.90–8.42)
Sex	Male	1461	2.11	(1.97–2.24)	24,703	19.64	(19.40–19.89)	9.31	(8.98–9.64)	7.08	(5.89–8.29)
	Female	1014	1.38	(1.29–1.47)	13,972	10.94	(10.76–11.13)	7.93	(7.58–8.29)	6.37	(5.27–7.48)
Age	15–24	525	1.48	(1.34–1.62)	3308	7.52	(7.27–7.78)	5.08	(4.67–5.54)	5.16	(4.41–5.92)
	25–34	805	2.67	(2.46–2.88)	8854	20.35	(19.92–20.77)	7.62	(7.13–8.15)	6.04	(4.91–7.19)
	35–44	333	1.58	(1.40–1.76)	8468	20.90	(20.46–21.35)	13.22	(11.96–14.62)	8.00	(6.66–9.36)
	45–54	260	1.35	(1.18–1.53)	10,052	23.13	(22.68–23.58)	20.10	(17.95–22.50)	8.58	(6.76–10.43)
	55–64	234	1.30	(1.13–1.48)	6368	15.89	(15.50–16.28)	12.21	(10.83–13.77)	7.52	(5.96–9.10)
	65+	318	1.51	(1.34–1.69)	1625	3.51	(3.34–3.68)	2.32	(2.08–2.60)	2.41	(1.92–2.91)
Race	Black	333	2.15	(1.91–2.40)	3830	11.24	(10.87–11.60)	5.23	(4.83–5.66)	4.92	(3.34–6.52)
	Other	28	0.96	(0.76–1.66)	868	4.43	(4.13–4.73)	4.61	(3.70–5.76)	5.36	(2.57–8.23)
	White	2114	1.63	(1.56–1.70)	33,977	17.47	(17.28–17.66)	10.72	(10.40–11.05)	7.35	(6.70–8.00)

[a] ICD codes E850–E858, X40–X44.
[b] AAPC from Joinpoint regression using age-adjusted mortality rates.
[c] Using comparability ratio of 1.195.

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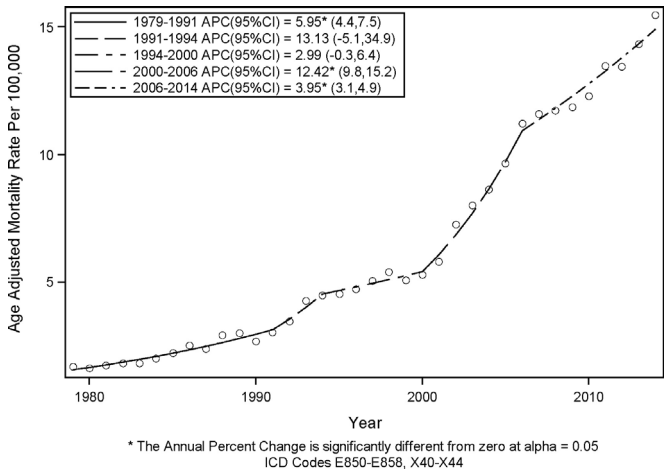

Fig. 3. US age-adjusted accidental drug poisoning mortality Joinpoint analysis trends, ages 15+.

also analyzed using the program, which calculates annual percent changes ($\exp(\beta)-1)*100$) based on Poisson model slope coefficients (β). The average annual percent change was then calculated as a weighted average of the slope coefficients ($\exp(\frac{\sum w_i\beta_i}{\sum w_i})-1)*100$), where the weight ($w_i$) represents the length of each corresponding interval. Standard errors for Joinpoint regression models were calculated as previously discussed.

County specific standardized rate ratios (SRRs) comparing 2013 to 1979 rates were used to identify geographic areas where accidental drug poisoning SRRs are the largest. Counties with zero deaths in 1979 and nonzero deaths in 2013 were suppressed ($n = 1675$) due to uninformative SRRs.

We examined drug poisoning mortality rates by High Intensity Drug Trafficking Areas (National HIDTA Assistance Center, n.d.) (see Appendix).We aggregated 2014 deaths and corresponding populations ages 15+ across the High Intensity Drug Trafficking counties within each High Intensity Drug Trafficking Area to calculate age-adjusted mortality. We calculated the age-adjusted drug poisoning mortality rate by sex for each High Intensity Drug Trafficking Area and compared those to the corresponding US rate by sex. We also compared High Intensity Drug Trafficking Area age-adjusted drug poisoning mortality rates to state-specific age-adjusted drug poisoning mortality rates (age 15+) excluding the High Intensity Drug Trafficking counties in each state.

2. Results

While deaths due to alcohol and other types of overdose have remained relatively stable since 1979, deaths due to overdose have risen exponentially (Fig. 1a–c). Female deaths due to accidental drug poisoning began increasing in the mid-1990s and increased dramatically in 2002, while rates in males began rising in the mid-1980s with a more rapid increase also beginning in 2002 (Fig. 1b). For males, deaths due to alcohol increased slightly in the late 2000s and have remained at the increased rate through 2014 (Fig. 1a).

From 1979 to 2014, deaths from accidental drug overdoses increased more than 6% on average each year from 2475 deaths in 1979 to 38,675 deaths in 2014 (Table 1). More deaths occurred among males, and increased at a slightly faster rate, with a more than 9-fold increase between 1979 and 2014 compared to a nearly 8-fold increase in females. In 1979, deaths rates for all age groups examined were similar (range = 1.30–2.67). Since 1979, deaths among all age groups have increased, with the smallest RR among 65+ year olds (2.32, 95% CI 2.08–2.60) and the largest RR increase among 45–54 year olds (20.10, 95% CI

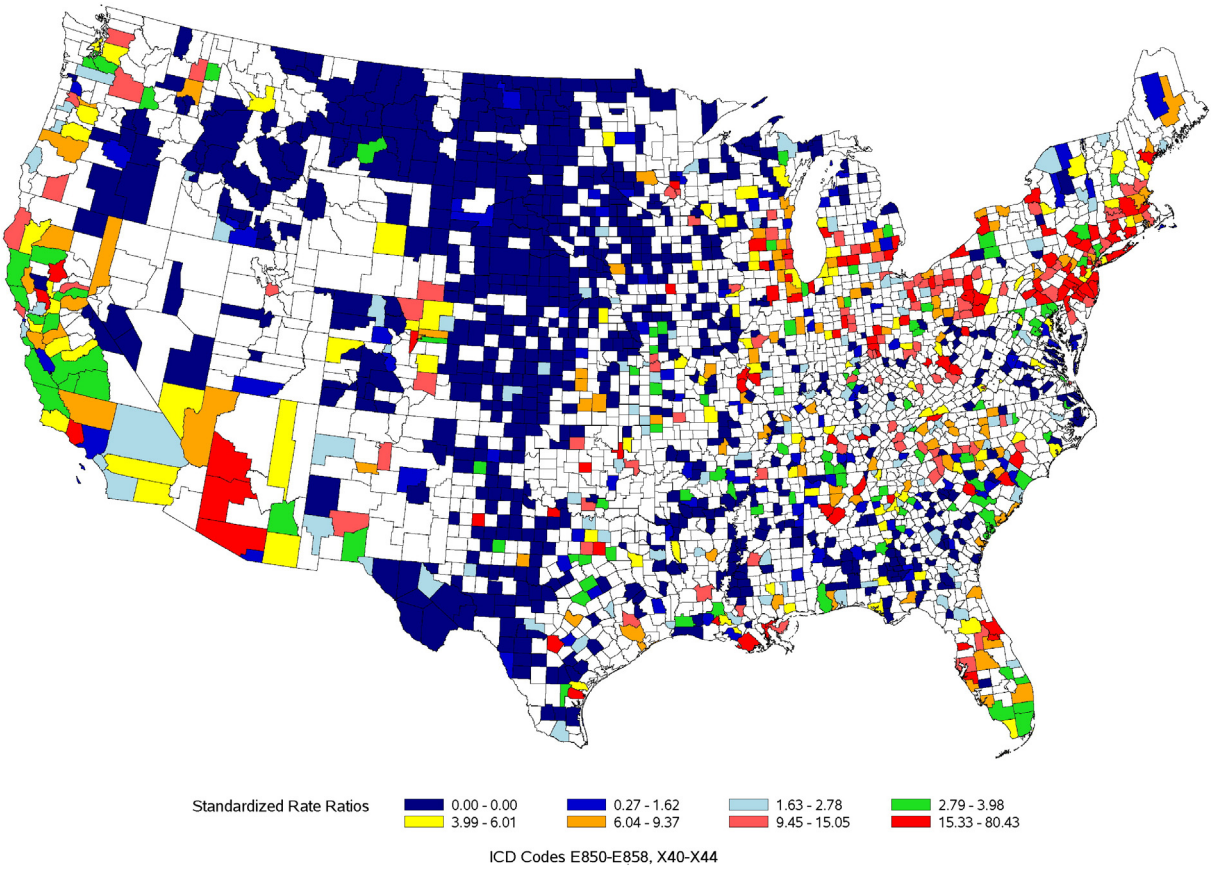

Fig. 4. Accidental drug poisoning mortality standardized rate ratios, ages 15+.

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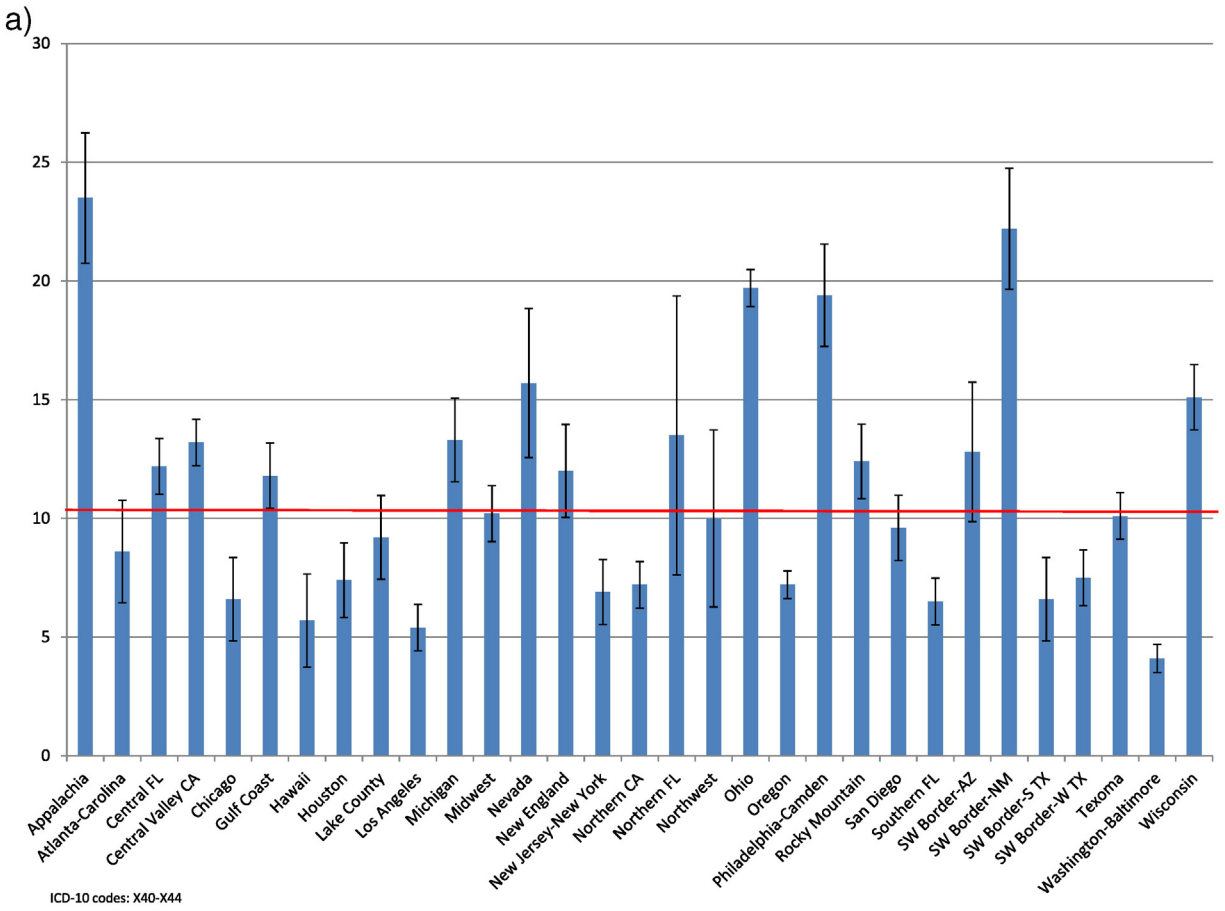

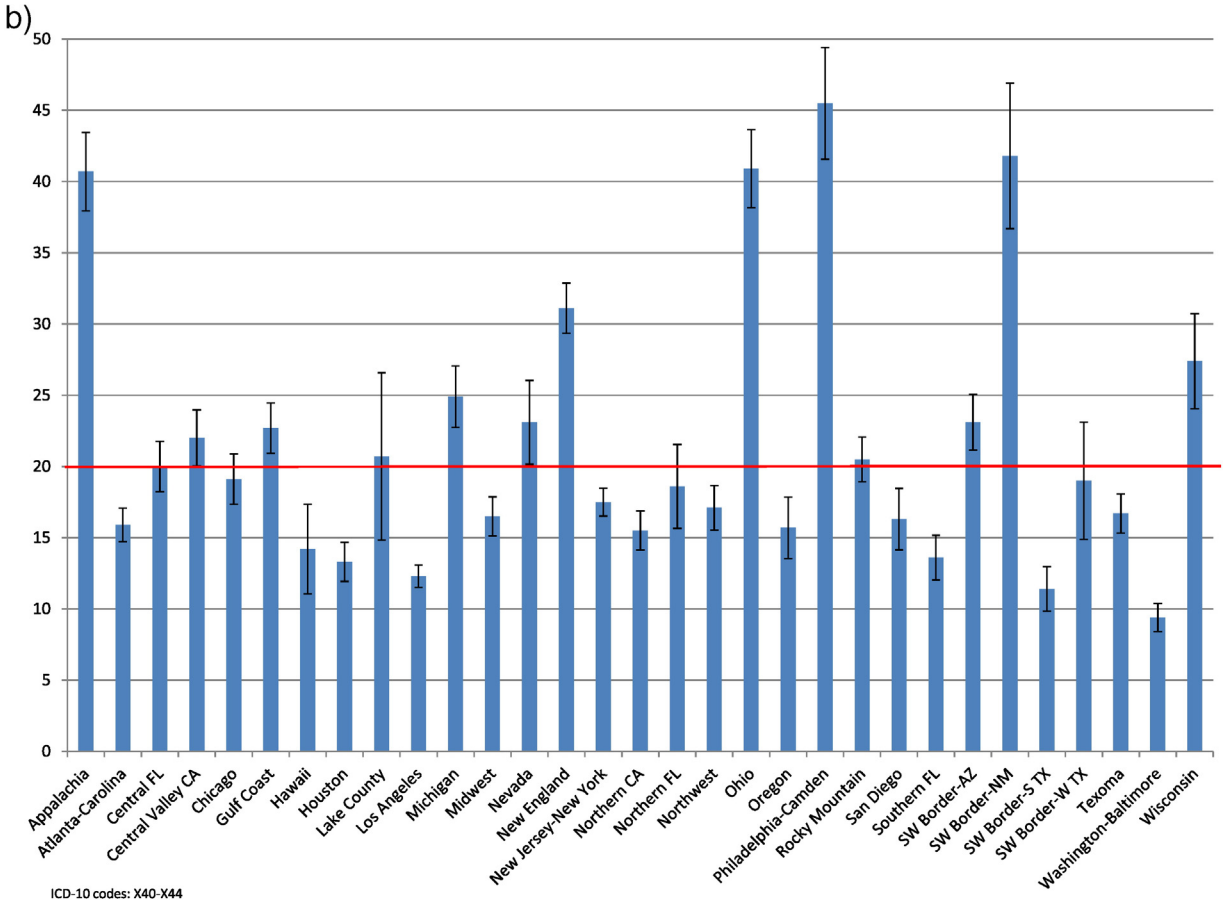

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17.95–22.50). In 1979, accidental drug overdose deaths occurred most frequently among 25–34 year olds and African Americans; in 2014, rates were highest among 45–54 year olds, a 20-fold increase, and in Whites, a nearly 11-fold increase (RR = 10.72, 95% CI 10.40–11.05). The average annual percent changes were more than 7% among males, 35–44, 45–54 and 55–64 year olds, and Whites, further reflecting the rapid rise in deaths in these groups.

Fig. 2a and b shows the US mortality rates for females and males ages 15 + by race. As seen through the 1980s and 1990s, African American women had higher rates of accidental poisoning than Whites or Other races. Beginning in the mid1990s, accidental poisoning mortality rates among White females began increasing dramatically and surpassed the rate in African-American women in the early 2000s. In males, drug poisoning mortality rates rose rapidly throughout the 1980s and 1990s in African-Americans. In Whites, rates began rising rapidly in the 1990s, surpassing rates in African-Americans in the mid2000s, corresponding to a decline in the rates of African-Americans.

The Joinpoint analysis for the total population identified four time points from 1979 to 2014 when the trajectory of the rate changed: 1991, 1994, 2000, and 2006, creating five rate segments (Fig. 3). Three of the time periods (1979–1991, 2000–2006, 2006–2014) had rates that were statistically significantly greater than zero, with the highest annual percent change (12.42, 95% CI 9.8–15.2) occurring in the 2000–2006 period. Joinpoint analyses were performed for each age group and race–sex group (Supplemental Graphs S1–S6). The age groups and race–sex group findings were similar to those found overall. Most groups examined experienced statistically significant changes in trend in either 2006 or 2007, with the annual percent change slowing in the 2006 (or 2007) to 2014 time period.

The county SRRs comparing 1979 to 2013 are shown in Fig. 4. Counties shown in white had no deaths in 1979 and nonzero deaths in 2013 so SRRs were suppressed due to instability (n = 1675). Most of the Midwest counties had no deaths in 1979 or in 2013 with SRRs of 0. Areas with the largest rates of change include Southern Michigan, Eastern Ohio/Western Pennsylvania, Eastern Pennsylvania/New Jersey and much of Southeastern New York, and Coastal New England. Rates increased by as much as 70-fold during that time period in several counties including Jefferson, Louisiana; Norfolk, Massachusetts; Franklin, Ohio; Montgomery, Ohio; Summit, Ohio; and Kanawha, WV.

Fig. 5a and b shows the 2014 age-adjusted accidental drug poisoning mortality rates for the 31 High Intensity Drug Trafficking Areas by gender. Overall, female rates are lower than male rates. For both females and males, approximately half of the High Intensity Drug Trafficking Areas have age-adjusted drug poisoning mortality rate lower than the US average (10.6/100,000 in females; 20.0/100,000 in males). For females, Appalachia has the highest rate followed by the SW Border of New Mexico, Ohio, Philadelphia–Camden, and Nevada. For males, Philadelphia–Camden has the highest rate, followed by the SW Border of New Mexico, Ohio, Appalachia, and New England. For both females and males, rates in High Intensity Drug Trafficking Areas vary 5 to 6-fold with differences up to 20/100,000 in females and 35/100,000 in males.

Fig. 6 compares the High Intensity Drug Trafficking Areas to the mortality rate of the state excluding the individual High Intensity Drug Trafficking counties. High Intensity Drug Trafficking Areas with high mortality rates are mostly concentrated in Appalachia and in the Southwest; state rates in these areas are correspondingly high. High Intensity Drug Trafficking Area mortality is also high in much of the West, in New England and in Florida, although surrounding state rates in these areas are lower. In contrast, the High Intensity Drug Trafficking Areas near the borders in California, Texas, and South Florida have mortality rates lower than the surrounding state rates.

3. Discussion

Accidental poisoning mortality rates in the US have risen over 6-fold since 1979 and this increase is almost entirely due to increasing drug poisoning mortality. Drug poisoning mortality rates have risen 6.65% on average from 1979 to 2014, and recent data suggest that they are still climbing in all age, race, and sex groups. This study confirms the Astone and Martin (Astone et al., 2015) hypothesis that increasing mortality rates in White women ages 15 to 64 may be attributed to rapidly increasing drug poisoning mortality. These findings also confirm rapidly rising rates of drug poisoning mortality in Whites ages 45–54 as found by Case and Deaton (Case and Deaton, 2015), but also rapidly rising rates in younger age groups, especially 35–44 year olds, and in 55–64 year olds. The effect of drug poisoning is not restricted to one age group. While the effect may be larger in Whites, all races have been affected.

The US counties with the highest SRRs were found in Southern Michigan, Eastern Ohio/Western Pennsylvania, Eastern Pennsylvania/New Jersey and much of Southeastern New York, and Coastal New England. While these counties had the highest SRRs, they do not necessarily correspond to those counties with the highest rates in 2013. Counties with higher rates in 1979 may have lower SRRs when compared to 2013 rates. Of the 10 counties with the highest 2013 drug poisoning AARs, two were in WV, two were in OK, two were in TX, 2 were in KS, and one each was in NM and WI. None were found in areas with the highest SRRs. This could indicate that areas with the highest SRRs warrant careful attention as rates have had large changes since 1979.

Interestingly, the counties with the highest mortality rates did not always directly correspond to those with the highest areas of drug trafficking. Most of the counties with the highest rates of increase were contained within High Intensity Drug Trafficking Areas, such as Jefferson, Louisiana (Gulf Coast HIDTA) and Kanawha, WV (Appalachia HIDTA), and three counties in the Ohio High Intensity Drug Trafficking Area (Franklin, Ohio; Montgomery, Ohio; Summit, Ohio). However, Norfolk, Massachusetts is not part of the New England High Intensity Drug Trafficking Area, and counties in the Midwest, California, and Texas have seen little to no increase in drug poisoning mortality rates. This seems to indicate that, especially in US border counties, drugs appear to pass through without affecting the death rates in the population.

We did find some evidence of high mortality rates among those High Intensity Drug Trafficking Areas included in the Heroin Response Strategy. For females, mortality rates were high in the Appalachia and Philadelphia–Camden Areas; for males rates were high in those two Areas and New England. However, Washington–Baltimore had the lowest mortality rates and was the only Area with rates below the county average. The New Jersey–New York Area was also low, while Areas such as Ohio, Nevada, Wisconsin, and SW Border of Arizona had high mortality rates, but have not been targeted for heroin intervention. It could be that these areas are being affected by other drugs, but also that additional resources are needed in more High Intensity Drug Trafficking Areas. While resources are justifiably being targeted to the High Intensity Drug Trafficking Areas, they must also be allocated to those non-HIDTA areas with rapidly increasing and currently high accidental drug poisoning mortality rates, such as Western Pennsylvania.

From 2004 to 2011, the rate of nonmedical use-related ED visits involving both opioid analgesics and benzodiazepines increased threefold (Jones and McAninch, 2015). Opioid pain relievers have been implicated in approximately 75% of accidental poisoning deaths (Paulozzi et al., 2001). An examination of opioid prescribing patterns found the highest rates in Appalachia and in Southern and Western states (McDonald et al., 2012), in partial agreement with the mortality findings described here. Mortality rates in Appalachia counties are some of

Fig. 5. a. Age-adjusted accidental drug poisoning mortality rates and 95% confidence intervals for females, 2014, by High Intensity Drug Trafficking Area. b. Age-adjusted accidental drug poisoning mortality rates and 95% confidence intervals for males, 2014, by High Intensity Drug Trafficking Area.

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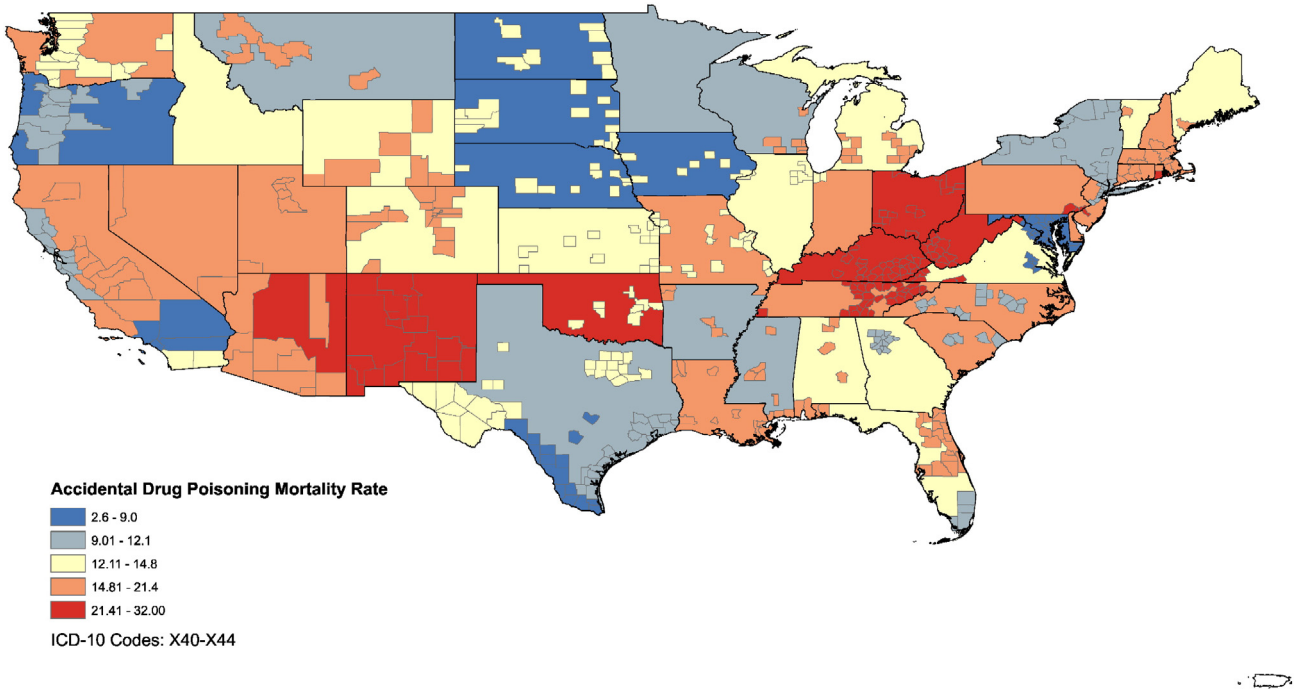

Fig. 6. Age-adjusted accidental drug poisoning mortality by state comparing High Intensity Drug Trafficking Area and non-High Intensity Drug Trafficking counties.

the highest in the nation, but they have not increased as rapidly since 1979 as those in other areas, such as Coastal New England. We found limited evidence of increasing rates in the West and only sporadic increases in Southern counties.

Rurality has been identified as an important factor in both opioid prescribing patterns and deaths (Rossen et al., 2013; Prunuske et al., 2014). In this study, we found slightly higher mortality rates in urban counties rather than rural counties (data not shown). Similarly, Rossen et al. (2013) found greater increases from 1999 to 2013 in rural areas, but the overall highest rates in core metropolitan areas. These findings may be due in part to the smaller populations and fewer deaths in rural counties, which can lead to more unstable annual estimates. It may also be due to differences in how, and the accuracy with which, cause of death recording is done by medical examiners or coroners in urban compared to rural areas. However, the rapid increases and high overall death rates for accidental poisoning in areas such as Appalachian Southern West Virginia and Kentucky provide important information about where prevention, intervention, and law enforcement resources should be targeted. Some of these counties in Appalachia are High Intensity Drug Trafficking counties, and while earlier interventions mainly involved marijuana (High-Intensity Drug Trafficking Areas, 1998), Appalachia is currently one of the Areas receiving resources in the Heroin Response Strategy.

This study was subject to some limitations. We used underlying cause of death as determined by the National Center for Health Statistics (accidental drug poisoning codes E860–E869 and X40–X49). These codes include accidental poisonings from both prescription and illicit drugs although we were not able to differentiate type of drug involved in the overdose in this study. We excluded deaths where the intent was unknown (Y10–Y19). We also only had underlying cause of death and not contributory causes, so we may have missed deaths where poisoning was coded as a contributory cause. Also, death certificates in general only capture accidental poisonings due to specific drugs, such as heroin or opioids, to the extent that they are recorded by the medical examiner or coroner determining cause of death (Slavova et al., 2015). There are no universal and systematic methods for classifying accidental poisoning death by drug based on toxicology screens. Future research differentiating type of drug, and systematic recording of drug-related causes of death are necessary to better understand the overdose epidemic and appropriately target resources. Analyses were limited to 1979 to 2014 to correspond to ICD-9 and ICD-10 revision coding because changes in underlying cause of death coding between the 8th and 9th revision made comparisons with earlier versions impossible.

The drug poisoning mortality epidemic is continuing to grow. While High Intensity Drug Trafficking Area resources are appropriately targeted at many areas in the US most affected by these deaths, rates are also rapidly rising in some non-High Intensity Drug Trafficking Areas. In addition, vital statistics systems should be strengthened to allow accurate and more expedient capture of cause of death information due to accidental poisonings.

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ypmed.2016.04.007.

Transparency Document

The Transparency document associated with this article can be found, in the online version.

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