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Increasing rates of methamphetamine/amphetamine-involved overdose hospitalizations in Washington State, 2010–2017

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ABSTRACT

Background and aims: In the United States, overdose deaths resulting from methamphetamine and other amphetamine-type stimulants (METH/AMPH) have been increasing. We describe rates and characterize patients hospitalized after a METH/AMPH-involved overdose in Washington State, to guide prevention and control measures.

Design, setting, participants: We conducted a trend analysis of hospitalized Washington State residents aged ≥15 years who received a METH/AMPH-involved overdose diagnosis in Washington's civilian hospitals and reported in the Comprehensive Hospital Abstract Reporting System.

Measurements: We used Joinpoint regression analysis to study trends in rates of hospitalized patients who received a METH/AMPH-involved overdose diagnosis during 2010–2017. We used 2016–2017 data to describe characteristics of patients with nonfatal and fatal outcomes and used chi-square test (for categorical variables) and Wilcoxon rank-sum test (for continuous variables) to compare characteristics of patients by outcome.

Findings: During 2010–2017, 3587 patients were hospitalized and received a METH/AMPH-involved overdose diagnosis. The age-adjusted rate for METH/AMPH-involved overdose hospitalization increased from 6.3/100,000 persons in 2010 to 8.5/100,000 persons in 2017. Patients aged ≥55 years had the greatest increase in rate of overdose hospitalizations. Among these patients, 86% also had a substance use disorder diagnosis involving substances other than METH/AMPH, and 35% experienced a polysubstance overdose.

Conclusions: We observed increasing rates of METH/AMPH-involved overdose hospitalizations in Washington State, particularly among persons aged ≥55 years. Approximately a third of patients also experienced a polysubstance overdose, which can be considered when designing interventions to address increasing rates of overdose hospitalizations in Washington State.

1. Introduction

Methamphetamine and other amphetamine-type psychostimulants (METH/AMPH) are highly addictive and widely misused (Heal et al., 2013; National Drug Intelligence Center, 2010). In the United States since 2008, misuse of METH/AMPH has been increasing (Center for Behavioral Health Statistics and Quality, 2018; Hunt, 2006; United Nations Office on Drugs and Crime (UNODC), 2014; Winkelman et al., 2018). This increase has been attributed to increased production and availability of purer and low-cost methamphetamine (US Department of Justice Drug Enforcement Administration (DEA), 2017). Recently, increases in METH/AMPH-involved overdose hospitalizations and deaths have been reported (Kariisa et al., 2019; Winkelman et al., 2018). In Washington State, the rate of psychostimulant-involved overdose deaths, largely due to methamphetamine, increased almost five-fold from 1.1/100,000 persons in 2008 to 5.3/100,000 persons in 2017 (Washington State Department of Health, 2018).

Limited studies are available that describe trends in rates for METH/AMPH-involved overdose hospitalization, characteristics of hospitalized patients who experienced a METH/AMPH-involved overdose, or the

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clinical features of hospitalized patients with nonfatal and fatal outcomes. To fill this gap, we conducted a trend analysis using Washington State's hospitalization data. This investigation provides crucial information on trends and characteristics of hospitalized patients who suffered a METH/AMPH-involved overdose to enhance Washington's prevention and control efforts for METH/AMPH-involved overdoses.

2. Methods

2.1. Study design

We conducted a trend analysis among patients hospitalized in Washington State during 2010–2017. Cases were defined as a discharge diagnosis of METH/AMPH-involved overdose in a Washington State resident aged ≥15 years old hospitalized in a civilian hospital during the investigation period. This age cut-off was chosen because children aged <15 years are more likely to have overdosed from therapeutic uses of METH/AMPH, rather than from recreational or nontherapeutic METH/AMPH use or abuse (Klein-Schwartz & McGrath, 2003). To identify cases, we reviewed the Washington State Department of Health's (DOH's) hospital discharge records collected using the Comprehensive Hospital Abstract Reporting System (CHARS). Civilian hospitals in Washington State are required by law to submit their hospital discharge records to DOH using CHARS (Washington State Department of Health, 2014). The discharge records list all patient diagnoses made during hospitalization in up to 25 diagnostic fields using the International Classification of Disease (ICD) codes (Centers for Disease Control and Prevention (CDC), 2020). Before October 1, 2015, the clinical modification of the Ninth Revision of ICD (ICD-9-CM) was used to code discharge diagnoses, this transitioned to the clinical modification of the Tenth Revision of ICD (ICD-10-CM) beginning October 1, 2015. We reviewed all 25 diagnostic fields and used the ICD-9-CM code 969.72 to identify patients diagnosed with METH/AMPH-involved overdose for data collected before October 1, 2015, and comparable ICD-10-CM codes T43.621A–T43.624A to identify patients on or after October 1, 2015.

To minimize double counting that might occur after hospital transfers, we identified patients with multiple hospitalizations during the analysis period using unique patient identification numbers and hospitalization dates. In Washington, hospitals assign each patient a unique patient identification number capable of tracking repeat visits. For each patient, we identified sequential hospitalizations with METH/AMPH-involved overdose diagnosis and determined the difference in days between them. When the difference was less than one day, we considered the two hospitalizations to be the same overdose episode and used the most recent hospitalization record data for analyses.

Because of the transition from ICD-9-CM to ICD-10-CM, not all diagnostic codes used to record discharge diagnoses and other comorbid conditions in ICD-9-CM matched with those in ICD-10-CM. Therefore, we limited our analyses of demographic and comorbid conditions to patients who were hospitalized and received a METH/AMPH-involved overdose diagnosis with nonfatal and fatal outcomes per ICD-10-CM diagnostic codes to hospitalizations that occurred only in 2016–2017. These diagnostic codes are not organized into clinically meaningful categories (i.e., different codes could be used to identify similar conditions). We used the clinical classification software, developed by the federal Agency for Healthcare Research and Quality, that groups related ICD-10-CM codes into clinically meaningful diseases (Agency for Healthcare Research and Quality, 2019). Of note, since this software only uses ICD-10-CM, our analysis was limited to data for the last two years. We reviewed diagnostic codes recorded for each patient and used the single-level clinical classification software to summarize and classify comorbid conditions into clinically meaningful disease categories. For cases identified, we reviewed all discharge diagnosis fields to identify substance-involved overdoses diagnosed during current hospitalization. Substances included alcohol, cocaine, and opioids, which we categorized into heroin and nonheroin opioids. From discharge records, we also identified history of substance use disorders diagnosed before this hospitalization. These included alcohol, cannabis, cocaine, opioids, sedatives and tobacco use disorders.

We used the patient's residential zip code to classify their residence type into urban or rural using the Rural-Urban Commuting Area codes, following the Washington State Department of Health's guidelines for using rural–urban classification systems for community health assessment (Washington State Department of Health, 2016). The Rural-Urban Commuting Area codes were developed to classify geographic regions based on population density, urbanization, and the size and direction of primary daily commuter flow between geographic locations (Rural Health Research Center, 2017).

2.2. Data analysis

We calculated hospitalized METH/AMPH-involved overdose and death rates using the postcensal estimated Washington State population for persons aged ≥15 years as the denominator (Office of Financial Management). We adjusted these rates by age using the 2000 standard U.S. population. We also calculated the proportion of hospitalized patients who had received a METH/AMPH-involved overdose diagnosis and died during their hospitalization. Rates of hospitalized METH/AMPH-involved overdose were further described by age group (15–24, 25–34, 35–44, 45–54 and ≥55 years) and sex, because recent literature suggests there are changing patterns in substance use, including methamphetamine, by these demographic characteristics (Chhatre et al., 2017). We used Joinpoint regression analysis for each group to describe trend in rates and to determine the average annual percentage change in rates over the study period (2010–2017) using zero inflection (Clegg et al., 2009). Average annual percentage change is a summary measure of the trend over a prespecified fixed interval. It allowed us to use a single number to describe the annual percentage changes over a period of multiple years (National Cancer Institute). We quantified hospitalizations and deaths using rates and proportions to describe distribution of patients by categorical variables including residence type (urban or rural), comorbid conditions, polysubstance overdose and disposition, and median and interquartile range to describe the length of hospital stay. We used chi-square test for categorical variables and Wilcoxon rank-sum test for continuous variables that were not normally distributed to compare characteristics of patients with fatal and non-fatal outcomes.

3. Ethical considerations

We used Washington State's hospitalization data without direct patient identifiers. The use of these data for this analysis was determined to be exempt from review by the Washington State Institutional Review Board. This project was determined to not be human subject research by the Centers for Disease Control and Prevention.

4. Results

During 2010–2017, we identified 3587 patients aged ≥15 years who resided in Washington State and were hospitalized and diagnosed at discharge with a METH/AMPH-involved overdose (Table 1). By age group, the highest proportion was seen among patients aged 25–34 years (n = 986 [27%]), and most patients were male (n = 2214 [62%]) (Table 1).

During 2010–2017, the age-adjusted rate of hospitalized METH/AMPH-involved overdose increased from 6.3/100,000 persons in 2010 to 8.5 hospitalizations/100,000 persons in 2017 with a peak of 9.9/100,000 persons in 2016 (Fig. 1). The average annual percentage change in age adjusted rates was 6.0% (95% CI: 2.6–9.5%) (Table 1 and Fig. 1). The largest annual increase in METH/AMPH-involved overdose hospitalization by age group was reported among patients aged ≥55 years

Table 1
Frequency, age-specific and age-adjusted* rates, annual percentage change in rates by age-group and sex for patients hospitalized and diagnosed with METH/AMPH involved overdose — Washington State, 2010–2017.

	Total number of patients	2010		2011		2012		2013		2014		2015		2016		2017		Average annual percentage change	95% CI
Age (yrs)	N (%)	No.	rate/ 100,000	No.	rate/ 100,000	No.	rate/ 100,000	No.	rate/ 100,000	No.	rate/ 100,000	No.	rate/ 100,000	No.	rate/ 100,000	No.	rate/ 100,000	%	
15–24	601 (17)	65	7.0	86	9.4	84	9.2	84	9.1	80	8.7	77	8.3	74	7.9	51	5.4	−3.2	−9.2–3.3
25–34	986 (27)	97	10.4	87	9.2	109	11.5	119	12.5	135	14.0	143	14.6	164	16.4	132	12.9	6.3	1.5–11.3
35–44	763 (21)	83	9.1	77	8.5	89	9.8	97	10.7	88	9.7	106	11.6	117	12.7	106	11.3	4.8	1.8–7.9
45–54	729 (20)	74	7.5	67	6.9	83	8.6	99	10.4	93	9.8	99	10.4	108	11.4	106	11.2	6.9	3.6–10.3
≥55	508 (14)	29	3.5	25	2.9	44	6.0	64	7.1	47	5.1	91	9.7	106	10.8	102	10.2	18.4	9.2–28.5
All	*3587 (100)*	*348*	*6.3*	*342*	*6.3*	*409*	*7.3*	*463*	*8.3*	*443*	*7.9*	*516*	*9.1*	*569*	*9.9*	*497*	*8.5*	*6.0*	*2.6–9.5*
Sex																			
Female	1373 (38)	152	5.9	135	5.2	166	6.4	176	6.5	160	6	200	7.3	207	7.5	177	6.3	3.1	−0.6–7.0
Male	2214 (62)	196	7.3	207	7.8	243	9.0	287	10.7	283	10.4	316	11.4	362	12.8	320	11.1	8.0	3.5–11.1

* Age adjusted using the 2000 standard U.S. population.

(18.4% [95% CI: 9.2–28.5%]) (Table 1). While males experienced an 8% increase, females experienced a 3.1% increase (Table 1).

Among hospitalized patients who received a METH/AMPH-involved overdose diagnosis, 103 (2.9%) died during hospitalization (Table 1). The age-adjusted death rates among these patients significantly increased from 0.2 deaths/100,000 persons in 2012 to a peak of 0.4 deaths/100,000 persons in 2015 then leveled off to 0.3 deaths/100,000 persons in 2016 and 2017 (Fig. 1). During 2016–2017, 1066 patients were hospitalized after a METH/AMPH-involved overdose (Table 2). Of these, 40 (4%) died during hospitalization. Most hospitalized patients who received a METH/AMPH-involved overdose diagnosis resided in urban areas (n = 986 [92%]). The most frequent comorbid conditions diagnosed among these patients included nervous system disorders (n = 695 [65%]), fluid and electrolyte disorders (n = 582 [55%]), and respiratory failure (n = 399 [37%]) (Table 2). Most patients (n = 921 [86%]) had a diagnosis of at least one substance use disorder that was not a METH/AMPH-use-disorder. The most frequent substance use disorders involved tobacco (n = 511 [48%]), opioids (n = 280 [26%]), and cannabis and alcohol (n = 162 [15%] and 161 [15%], respectively). Thirty-five percent of patients (n = 373) received a diagnosis of drug overdose involving other substances in addition to METH/AMPH (polysubstance overdose). Opioid (n = 304 [29%]) was the most frequent drug class involved in polysubstance overdoses (Table 2).

Hospitalized patients with fatal outcomes, compared with patients with nonfatal outcomes, had a statistically significant longer median length of hospital stay (4 days vs 3 days), higher proportions with fluid and electrolyte disorder (80% vs 54%), respiratory failure (93% vs 35%), acute and unspecified renal failure (70% vs 29%), hepatitis (30% vs 17%), liver disease (48% vs 14%), congestive heart failure (25% vs 12%), aspiration (38% vs 12%), and septicemia (40% vs 10%) (Table 2). Hospitalized patients with fatal outcomes also had a higher proportion of polysubstance overdoses involving cocaine, compared with those with nonfatal outcomes (13% vs 4%). A lower proportion of patients with fatal outcomes were diagnosed with intentional self-harm and suicide (5% vs 17%), compared with those with non-fatal outcomes (Table 2).

5. Discussion

Our study reports increasing rates of hospitalizations and deaths during hospitalization among Washington State residents who received a METH/AMPH-involved overdose diagnosis, with the highest increase in hospitalization reported among patients 55 years and above. Increasing rates of METH/AMPH-involved overdose hospitalizations have also been reported in a recent national study that observed an approximate twofold increase in amphetamine-related hospitalizations in western states during 2003–2015 (Winkelman et al., 2018). Another national study among patients with opioid use disorder entering drug treatment programs during 2011–2017, reported increasing methamphetamine use, especially in the western region (Ellis et al., 2018).

National efforts to reduce the prescription of opioids might have contributed to the increase in misuse of nonprescription drugs, such as methamphetamine and heroin among persons who use drugs (Centers for Disease & Prevention, 2012; Compton et al., 2016; Ellis et al., 2018; Franklin et al., 2012). Data from Washington State indicate a marginal increase in all opioid-involved overdose hospitalization rates, from 18.1/100,000 persons in 2010 to 20.2/100,000 persons in 2017, driven by heroin-involved overdose rates that more than doubled during the same period, from 2.1/100,000 persons in 2010 to 4.7/100,000 persons in 2017 (Washington State Department of Health, 2018). In our study the age-adjusted rates for hospitalizations involving METH/AMPH overdose also increased from 6.3/100,000 persons in 2010 to 8.5/100,000 persons in 2017, and almost twice the above reported rate for heroin overdose hospitalization in Washington State (Washington State Department of Health, 2018). It is possible that the increased availability and use of naloxone is reducing the rates for opioid-involved overdose

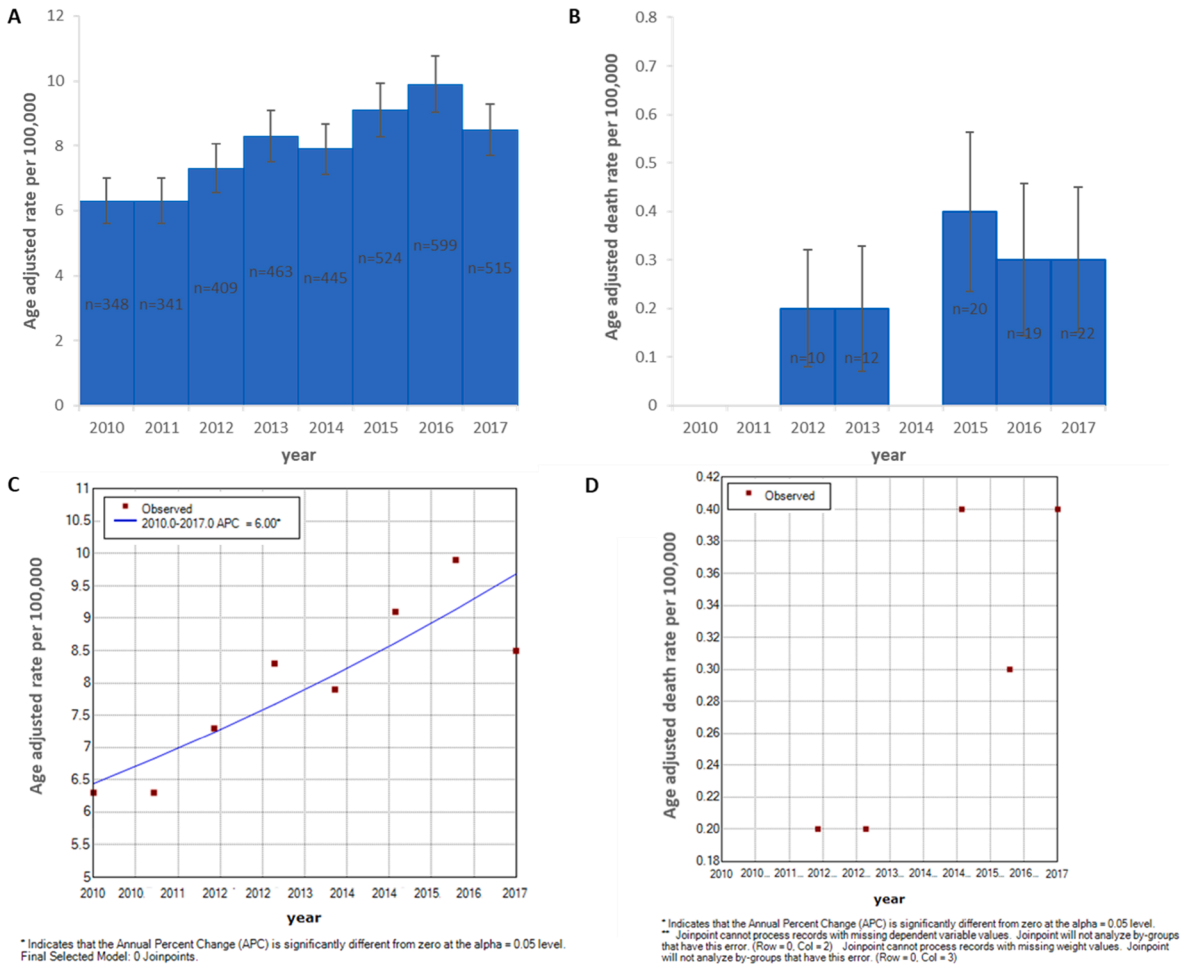

Fig. 1. Frequency, age-adjusted rates* and confidence interval for (A) hospitalized patients diagnosed with METH/AMPH involved overdose, (B) deaths among hospitalized patients diagnosed with METH/AMPH involved overdose and Joinpoint regression for (C) hospitalized patients diagnosed with METH/AMPH involved overdose and (D) deaths** among hospitalized patients diagnosed with METH/AMPH involved overdose — Washington State, 2010–2017 (*age adjusted using the 2000 standard U.S. population. **number of deaths <10 not provided and rates unstable where number of deaths are <20).

hospitalization (Doyon et al., 2016; Walley et al., 2013).

Patients aged ≥55 years reportedly had the highest increase in rates for METH/AMPH-involved hospitalization during 2010–2017, compared with other age groups. This might be attributable to increased use of methamphetamine by persons in this age group as has been observed in other studies (Colliver et al., 2006; Wu & Blazer, 2011). Alternatively, given that older persons are more likely to have underlying comorbidities, they might be predisposed to developing severe illness after methamphetamine overdose, compared with younger users (Darke et al., 2008).

Despite the small numbers for deaths, we observed increasing age-adjusted death rates among hospitalized patients diagnosed with METH/AMPH-involved overdose. A similar trend for increasing METH/AMPH-involved overdose death rates has been reported both nationally and in Washington State (Alcohol Drug Abuse Institute (ADAI), 2018; Kariisa et al., 2019). This increase may be due to changing patterns of methamphetamine use, including the emerging concurrent use of multiple substances with methamphetamines (Betts et al., 2015; Caleb Banta-Green et al., 2015. Polysubstance use has been shown to increase the risk for overdose and death (Arria et al., 2008; Kuo et al., 2011). There have also been reports of methamphetamine contaminated with more potent substances such as fentanyl (Drug Enforcement Administration (DEA), 2018). Fentanyl is a highly potent synthetic opioid that has been linked to a substantial number of opioid-related deaths in the United States (Gladden et al., 2016; Peterson et al., 2016). A cross-sectional study of drug test results for urine collected from patients across the United States found a 778% increase in nonprescribed fentanyl among patients with methamphetamine-positive test, increasing from 0.9% in 2013 to 7.9% in 2018 (LaRue et al., 2019). The increasing use of methamphetamine together with fentanyl might have resulted in the increased METH/AMPH-involved overdose hospitalizations that were observed in our study (LaRue et al., 2019).

5.1. *Limitations*

Our study had several limitations. First, we used hospital discharge data for this analysis, which are primarily used for billing purposes and might not accurately report on patients diagnosed with METH/AMPH-involved overdose. Nosologists assign diagnostic codes based on physician and provider notes that can be misinterpreted or miscoded. However, any bias due to miscoding is likely to be relatively constant over time. Furthermore, reports using mortality data collected in Washington State have similar trends in methamphetamine-involved overdose deaths over the study period (Alcohol Drug Abuse Institute (ADAI), 2018). Second, ICD 9 CM codes transitioned to ICD 10 CM codes in October 2015. The ICD 10 CM codes allow for the separation of drug poisoning from adverse drug reactions. However, the ICD 9 CM codes do not have this capability. This may have inflated the number of cases of METH/AMPH-involved overdose identified prior to the transition in October 2015. In addition, the discharge codes include both illicit and prescribed stimulants; thus, we are unable to determine the extent to which these trends are being driven by illicit or prescribed stimulants

Table 2
Comparison of characteristics of patients hospitalized and diagnosed with METH/AMPH-involved overdose by their disposition status (fatal and non-fatal) — Washington State, 2016–2017.

Characteristic	All N = 1066 No. (%)	Fatal N = 40 No. (%)	Nonfatal N = 1026 No. (%)	*P* value
Residence type				
Rural	80 (8)	4 (10)	76 (7)	
Urban	986 (92)	36 (90)	950 (93)	0.54
Length of hospital stay; median (interquartile range)	3 (1–5)	4 (3–10)	3 (1–5)	<0.01
Comorbidities				
Acute and unspecified renal failure	328 (31)	28 (70)	300 (29)	<0.01
Anxiety disorders	274 (26)	6 (15)	268 (26)	0.11
Aspiration pneumonitis; food/vomitus	134 (13)	15 (38)	119 (12)	<0.01
Cardiac dysrhythmias	202 (19)	11 (28)	191 (19)	0.16
Congestive heart failure; non-hypertensive	134 (13)	10 (25)	124 (12)	0.02
Essential hypertension	236 (22)	10 (25)	226 (22)	0.66
Fluid and electrolyte disorders	582 (55)	32 (80)	550 (54)	<0.01
Hepatitis	184 (17)	12 (30)	172 (17)	0.03
Hypertension with complications and secondary hypertension	110 (10)	4 (10)	106 (10)	0.95
Injuries and conditions due to external causes	127 (12)	4 (10)	123 (12)	0.70
Intentional self-harm and suicide attempts	177 (17)	2 (5)	175 (17)	0.04
Liver disease	159 (15)	19 (48)	140 (14)	<0.01
Mood disorders	322 (30)	8 (20)	314 (31)	0.15
Nervous system disorders	695 (65)	28 (70)	667 (65)	0.52
Respiratory failure; insufficiency; arrest (adult)	399 (37)	37 (93)	362 (35)	<0.01
Septicemia	116 (11)	16 (40)	100 (10)	<0.01
Drug related substance-use-disorders*				
At least one non-METH/AMPH substance use disorder	921 (86)	34 (85)	887 (86)	0.79
Alcohol	161 (15)	8 (20)	153 (15)	0.38
Cannabis	162 (15)	5 (13)	157 (15)	0.63
Cocaine	53 (5)	2 (5)	51 (5)	0.99
Opioid	280 (26)	12 (30)	268 (26)	0.58
Sedative	30 (3)	1 (3)	29 (3)	0.90
Tobacco	511 (48)	14 (35)	497 (48)	0.10
Other drugs involved in overdose				
Amphetamine alone	693 (65)	22 (55)	671 (65)	0.50
Amphetamine plus other substances*	373 (35)	18 (45)	355 (35)	0.50
Alcohol	56 (5)	2 (5)	54 (5)	0.94
Cocaine	47 (4)	5 (13)	42 (4)	0.01
Opioids (including heroin)	304 (29)	13 (33)	291 (28)	0.57
Heroin	164 (15)	7 (18)	157 (15)	0.71
Non-heroin opioids	154 (14)	7 (18)	147 (14)	0.58

* Categories below are not mutually exclusive.

though the majority would be illicit stimulants. Third, METH/AMPH-involved overdose patients who develop severe complications might have died soon after arriving at the hospital before a METH/AMPH-involved overdose diagnosis could be made underestimating our rates. However, the small numbers for deaths could have resulted in unstable rate estimates and should therefore be interpreted with caution. Fourth, for patients diagnosed with comorbidities, the possibility exists that certain conditions classified as comorbidities were caused by METH/AMPH. We were unable to distinguish these comorbidities from other preexisting underlying conditions not associated with METH/AMPH use. Lastly, rates estimated in our study only accounted for hospitalized patients who received a METH/AMPH-involved overdose diagnosis even in cases where METH/AMPH might not be the primary cause of hospitalization.

6. Conclusions

This large analysis of hospital discharge data in Washington showed increasing rates of hospitalized METH/AMPH-involved overdose. These trends could be due to increasing availability of methamphetamine, polysubstance use that includes methamphetamine, and contamination of methamphetamine with other more potent substances. Older persons constitute a high proportion of METH/AMPH-involved overdose hospitalizations in Washington State. These findings highlight the need for intensified efforts to reduce METH/AMPH-involved overdose hospitalization with special focus on polysubstance use. Specifically including interventions tailored to older persons in prevention and control measures could have a substantial impact on Washington METH/AMPH involved overdose hospitalizations.

CRediT authorship contribution statement

Henry Njuguna: Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing. **Jian Gong:** Formal analysis, Writing - review & editing. **Katie Hutchinson:** Writing - review & editing. **Mamadou Ndiaye:** Writing - review & editing. **Jennifer Sabel:** Conceptualization, Methodology, Writing - review & editing. **Cathy Wasserman:** Conceptualization, Methodology, Supervision, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Agency for Healthcare Research and Quality (2019). Clinical Classifications Software (CCS) for ICD-10-PCS (beta version). Healthcare Cost and Utilization Project (HCUP). Retrieved from: www.hcup-us.ahrq.gov/toolssoftware/ccs10/ccs10.jsp. Accessed.

Alcohol Drug Abuse Institute (ADAI) (2018). Washington State Opioid/Major Drug Interactive Data: Methamphetamine trends across Washington state. Retrieved from: http://adai.uw.edu/wadata/methamphetamine.htm. Accessed.

Arria, A. M., Caldeira, K. M., O'Grady, K. E., Vincent, K. B., Johnson, E. P., & Wish, E. D. (2008). Nonmedical use of prescription stimulants among college students: Associations with attention-deficit-hyperactivity disorder and polydrug use. *Pharmacotherapy, 28*(2), 156–169.

Betts, K. S., McIlwraith, F., Dietze, P., Whittaker, E., Burns, L., Cogger, S., & Alati, R. (2015). Can differences in the type, nature or amount of polysubstance use explain the increased risk of non-fatal overdose among psychologically distressed people who inject drugs? *J Drug alcohol dependence, 154*, 76–84.

Caleb Banta-Green, S. K., Ohta, J., Taylor, M., Sylla, L., Tinsley, J., Smith, R., Couper, F., Harruff, R., Freng, S., & Von Derau, K. (2015). 2015 Drug Use Trends for King County, Washington. Retrieved from: http://adai.uw.edu/pubs/pdf/2015druguset rends.pdf. Accessed 2/26/2019 2019.

Center for Behavioral Health Statistics and Quality (2018). Results from the 2017 national survey on drug use and health: Detailed tables. Retrieved from: htt ps://www.samhsa.gov/data/sites/default/files/cbhsq-reports/NSDUHDetailedTab s2017/NSDUHDetailedTabs2017.pdf. Accessed 5/23/2019.

Centers for Disease, C., & Prevention (2012). CDC grand rounds: prescription drug overdoses – A U.S. epidemic. MMWR Morb Mortal Wkly Rep 61(1), 10–13.

Centers for Disease Control and Prevention (CDC) (2020). Classification of Diseases, Functioning, and Disability. Retrieved from: https://www.cdc.gov/nchs/icd/index.htm. Accessed July 15 2020.

Chhatre, S., Cook, R., Mallik, E., & Jayadevappa, R. (2017). Trends in substance use admissions among older adults. *BMC Health Services Research, 17*(1), 584.

Clegg, L. X., Hankey, B. F., Tiwari, R., Feuer, E. J., & Edwards, B. K. (2009). Estimating average annual per cent change in trend analysis. *Statistics in Medicine, 28*(29), 3670–3682.

Colliver, J., Compton, W., Gfroerer, J., & Condon, T. (2006). Projecting drug use among aging baby boomers in 2020. *Annals of Epidemiology, 16*(4), 257–265.

Compton, W. M., Jones, C. M., & Baldwin, G. T. (2016). Relationship between nonmedical prescription-opioid use and heroin use. *New England Journal of Medicine, 374*(2), 154–163.

Darke, S., Kaye, S., McKetin, R., & Duflou, J. (2008). Major physical and psychological harms of methamphetamine use. *Journal of Drug and Alcohol Review, 27*(3), 253–262.

Doyon, S., Benton, C., Anderson, B. A., Baier, M., Haas, E., Hadley, L., Maehr, J., Rebbert-Franklin, K., Olsen, Y., & Welsh, C. (2016). Incorporation of poison center services in a state-wide overdose education and naloxone distribution program. *American Journal on Addictions, 25*(4), 301–306.

Drug Enforcement Administration (DEA) (2018). 2018 National Drug Threat Assessment. Retrieved from: https://www.dea.gov/sites/default/files/2018-11/DIR-032-18%202018%20NDTA%20final%20low%20resolution.pdf. Accessed 04-24-2019 2019.

Ellis, M. S., Kasper, Z. A., & Cicero, T. J. (2018). Twin epidemics: The surging rise of methamphetamine use in chronic opioid users. *Drug and Alcohol Dependence, 193*, 14–20.

Franklin, G. M., Mai, J., Turner, J., Sullivan, M., Wickizer, T., & Fulton-Kehoe, D. (2012). Bending the prescription opioid dosing and mortality curves: Impact of the Washington State opioid dosing guideline. *American Journal of Industrial Medicine, 55*(4), 325–331.

Gladden, R. M., Martinez, P., & Seth, P. (2016). Fentanyl Law Enforcement Submissions and Increases in Synthetic Opioid-Involved Overdose Deaths - 27 States, 2013–2014. *MMWR. Morbidity and Mortality Weekly Report, 65*(33), 837–843.

Heal, D. J., Smith, S. L., Gosden, J., & Nutt, D. J. (2013). Amphetamine, past and present–a pharmacological and clinical perspective. *Journal of Psychopharmacology, 27*(6), 479–496.

Hunt, D. E. (2006). Methamphetamine abuse: Challenges for law enforcement and communities. National Institute of Justice Journal, 254, 24–27.

Kariisa, M., Scholl, L., Wilson, N., Seth, P., & Hoots, B. (2019). Drug overdose deaths involving cocaine and psychostimulants with abuse potential - United States, 2003–2017. *MMWR. Morbidity and Mortality Weekly Report, 68*(17), 388–395.

Klein-Schwartz, W., & McGrath, J. (2003). Poison centers' experience with methylphenidate abuse in pre-teens and adolescents. *Journal of the American Academy of Child and Adolescent Psychiatry, 42*(3), 288–294.

Kuo, C. J., Liao, Y. T., Chen, W. J., Tsai, S. Y., Lin, S. K., & Chen, C. C. (2011). Causes of death of patients with methamphetamine dependence: A record-linkage study. *Drug and Alcohol Review, 30*(6), 621–628.

LaRue, L., Twillman, R. K., Dawson, E., Whitley, P., Frasco, M. A., Huskey, A., & Guevara, M. G. (2019). Rate of fentanyl positivity among urine drug test results positive for cocaine or methamphetamine. *JAMA Network Open, 2*(4), e192851. https://doi.org/10.1001/jamanetworkopen.2019.2851.

National Cancer Institute. Average Annual Percent Change (AAPC) and Confidence Interval. Retrieved from: https://surveillance.cancer.gov/help/joinpoint/setting-parameters/method-and-parameters-tab/apc-aapc-tau-confidence-intervals/average-annual-percent-change-aapc. Accessed April 29 2020.

National Drug Intelligence Center (2010). National drug threat assessment 2010. Retrieved from: https://www.justice.gov/archive/ndic/pubs38/38661/38661p.pdf. Accessed 5/23/2019.

Office of Financial Management. Estimates of April 1 population by age, sex, race and Hispanic origin. Retrieved from: https://www.ofm.wa.gov/washington-data-research/population-demographics/population-estimates/estimates-april-1-population-age-sex-race-and-hispanic-origin. Accessed 6/10/2019 2019.

Peterson, A. B., Gladden, R. M., Delcher, C., Spies, E., Garcia-Williams, A., Wang, Y., Halpin, J., Zibbell, J., McCarty, C. L., DeFiore-Hyrmer, J., DiOrio, M., & Goldberger, B. A. (2016). Increases in Fentanyl-Related Overdose Deaths - Florida and Ohio, 2013–2015. *MMWR. Morbidity and Mortality Weekly Report, 65*(33), 844–849.

Rural Health Research Center (2017). Rural–urban commuting area codes (RUCAs). Retrieved from: http://depts.washington.edu/uwruca/. Accessed Jan 28, 2019 2019.

United Nations Office on Drugs and Crime (UNODC) (2014). World Drug Report 2014. Retrieved from: https://www.unodc.org/documents/wdr2014/World_Drug_Report_2014_web.pdf. Accessed 5/23/2019.

US Department of Justice Drug Enforcement Administration (DEA) (2017). 2017 National Drug Threat Assessment. Retrieved from: https://www.dea.gov/sites/default/files/2018-07/DIR-040-17_2017-NDTA.pdf. Accessed 5/23/2019.

Walley, A., Xuan, Z., Hackman, H., Quinn, E., Doe-Simkins, M., Sorensen-Alawad, A., Ruiz, S., & Ozonoff, A. (2013). Opioid overdose rates and implementation of overdose education and nasal naloxone distribution in Massachusetts: Interrupted time series analysis. *BMJ, 346*, Article f174.

Washington State department of Health (2014). Comprehensive Hospital Abstract Reporting System (CHARS) Procedure Manual for Submiting Discharge Data. (Vol. 2020).

Washington State Department of Health (2016). Guidelines for Using Rural-Urban Classification Systems for Community Health Assessment. Retrieved from: https://www.doh.wa.gov/Portals/1/Documents/1500/RUCAGuide.pdf. Accessed 5/23/2019.

Washington State Department of Health. (2018). Washington State Residents Drug Overdose Quarterly Report. Retrieved from: https://www.doh.wa.gov/Portals/1/Documents/8300/wa_lhj_quarterly_report_18_1_2_pub.html. Accessed 5/23/2019.

Winkelman, T. N. A., Admon, L. K., Jennings, L., Shippee, N. D., Richardson, C. R., & Bart, G. (2018). Evaluation of Amphetamine-related hospitalizations and associated clinical outcomes and costs in the United States. *JAMA Network Open, 1*(6), e183758. https://doi.org/10.1001/jamanetworkopen.2018.3758.

Wu, L.-T., & Blazer, D. G. (2011). Illicit and nonmedical drug use among older adults: A review. *Journal of Aging and Health, 23*(3), 481–504.