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Opioid-stimulant trends in overdose toxicology by race, ethnicity, & gender: An analysis in Delaware, 2013–2019

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Abstract
Recent upticks of stimulant presence in overdose deaths suggest the opioid epidemic is morphing, which raises questions about what drugs are involved and who is impacted. We investigate annual and growth rate trends in combined opioid-stimulant overdose toxicology between 2013 and 2019 for White, Black, and Hispanic male and female decedents in Delaware. During these years, toxicology shifted to illegal drugs for all with fentanyl leading the increase and opioid-cocaine combinations rising substantially. While combined opioid-cocaine toxicology grew among Black and Hispanic Delawareans, White males continue to report the highest rates overall. These findings depart from historical patterns and may challenge existing opioid epidemic policies.

Keywords: Opioids; cocaine; race; gender; overdose trends

Introduction

In recent years, an uptick in stimulant substance use and its emergent role in combination with opioids—especially fentanyl—in overdose deaths is causing concern that the United States is now in a fourth-wave of its opioid epidemic (Al-Tayyib et al., 2017; Center for Behavioral Health Statistics and Quality [CBHSQ], 2020; Ciccarone, 2021; Hedegaard et al., 2021; Jenkins, 2021; Jones et al., 2017; Jones et al., 2020; Lopez, 2020; Vestal, 2019). This worry reached the Office of National Drug Control Policy (2020), which announced a new focus on stimulants (e.g., cocaine, methamphetamines) in addition to ongoing attention to opioids. Increased attention to rising stimulant use and combined opioid-stimulant use, espe-cially, is crucial given the increased overdose risk associated with these combinations and the challenges they pose to public health (LaRue et al., 2019; Jones et al., 2020). As such, the rise in overdose deaths with both

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stimulants and opioids raises new questions that require our attention: Which opioid-stimulant combinations are most problematic and how are these combinations patterned across race/ethnicity- and gender-specific demographic groups?

Concerns about opioid-stimulant overdoses, their presence among diverse race-gender groups, and our nation's history with prior drug crises justify investigating these questions. For example, the harm brought about by drug crises—whether through the consequences of drug use, drug markets, or the policies that follow—has, historically, been patterned by race/ethnicity, gender, and social class (see Courtwright, 2001; Provine, 2011; Reinarman, 1994). Previous opioid problems hit the Black population in urban areas hardest and men much more so than women (National Institute on Drug Abuse [NIDA], 2020; Dluzen & Liu, 2008; Agar & Reisinger, 2002; Marks, 1974). In addition, problems with stimulants in the past have also varied by race and gender, with White Americans being disproportionately troubled by methamphetamine and powder cocaine use, and Black Americans in urban areas being troubled by crack cocaine use (Golub & Johnson, 1996; Reinarman & Levine, 1997). While men's rates of problematic substance use have consistently outpaced women's across drug types, there have been notable variations among women and men by race and ethnic group (CBHSQ, 2017). For example, during the early years of the current opioid epidemic—which featured heavy misuse of prescription (Rx) opioids—the overdose gap between men and women narrowed, only to expand again in later years when illicit opioids (e.g., heroin, fentanyl) became more prevalent (Campbell et al., 2010; Eeckhaut et al., 2020; Ho, 2020).

Given today's emphasis on evidence-based policies, research must study how new drug developments might vary across groups over time. In the past, however, policymakers have often adopted "one-size fits all" interventions or have responded unequally—and at times unjustly—to diverse groups impacted by substance use. Contemporary responses to problematic drug use may be improved by identifying how groups are being impacted and by which substance(s), and then summarily tailoring interventions to meet their needs. Overdose death toxicology is one metric that can be used to identify how specific substances are impacting diverse groups. Our purpose is to investigate the rise of stimulants in overdose death toxicology reports between 2013 and 2019 in Delaware and how stimulant presence in combination with opioids may be patterned by race/ethnicity and gender. Findings from this investigation can help inform current policies and practices while also cautioning us to potential inequities within them.

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Race and gender overdose death rates in the opioid epidemic

A central feature of the current opioid epidemic is its origins in iatrogenic addiction to Rx opioids (Kolodny et al., 2015). Pharmaceutical companies' misrepresentation of Rx opioid risks and local lobbying efforts facilitated over-prescribing practices by physicians in the late 1990s and 2000s (Herzberg, 2020). This practice led to a ten-year (2000–2010) period of high rates of overdose deaths from Rx opioids in White rural and suburban communities (Rich et al., 2019; Seth et al., 2018). The gap between males and females narrowed during these years because of prescribing practices and consumption patterns of Rx opioids (Jalal et al., 2018; Eeckhaut et al., 2020; Lipato & Terplan, 2018). However, White males still led all demographic groups (Wilson et al., 2020).

In contrast to the predominantly criminal justice-oriented drug policies of the 20th century, today's opioid problem is addressed with a relatively greater public health focus that begins by defining addiction as a disease of the brain. Many scholars attribute the differential policy approaches of past and current drug epidemics to the demographic characteristics of those involved, especially as Rx opioid use and overdose deaths have impacted rural and suburban White communities (Hansen & Netherland, 2016; James & Jordan, 2018; Lassiter, 2015; Netherland & Hansen, 2017). Yet, despite the move toward more "public health" approaches, the resulting attempts to control Rx opioid prescribing may have contributed to a shift to cheaper, more accessible, and more potent illicit drugs. Seizures, overdose deaths, and use of illegal opioids (such as heroin and fentanyl) have risen concurrently with Rx drug controls (Cerdá et al., 2021; Compton et al., 2016; Kertesz & Gordon, 2019). For instance, heroin users commonly report initiating opioid use with Rx opioids (Compton et al., 2016). Moreover, one study found links between the implementation of prescription drug monitoring programs (PDMPs) and heroin overdose deaths (Martins et al., 2019).

Importantly, the shift away from Rx opioids to illicit drugs has contributed to changing demographic patterns of overdose death and suggests unique pathways to substance use and overdose death by race/ethnicity. White opioid use disorder (OUD) patients report a wider variety and greater number of substances used before turning to non-pharmaceutical opioids than do Black patients (Deutsch-Link et al., 2021). Similarly, White heroin users more frequently report Rx opioids as their initial drug of choice prior to using heroin (Martins et al., 2017). However, the growth in illegal opioid availability ultimately corresponded with an increase in both overdose mortality rates and representation of racial/ethnic minorities in overdose deaths, although White males are still the highest represented group among overdose decedents (Jalal et al., 2018).

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Many scholars have contested the framing of the opioid epidemic as a predominantly "White problem" and suggest that this focus contributes to a neglect of the impact the epidemic has had on all racial groups (Drake et al., 2020; Hansen & Roberts, 2012; Hansen & Netherland, 2016; James & Jordan, 2018; Netherland & Hansen, 2017; Om, 2018). For instance, Alexander et al. (2017) suggest that opioid death rates spanning 2000 to 2015 illustrate two periods with the first one showcasing an increase among White Americans that largely resulted from prescriptions (2000–2010) and a second period where Black and White overdose mortality rates increased similarly with the rise of heroin and fentanyl use. Recently, the opioid epidemic has witnessed a greater prevalence of Black Americans using Rx opioids in combination with heroin and cocaine (Kandel et al., 2017). In fact, cocaine has been indicated as the substance next in line to heroin in importance regarding its association with increasing synthetic opioid deaths (Kandel et al., 2017). Similarly, while overdose deaths rates within the Hispanic population consistently trailed White death rates from 2000 to 2017, Cano (2020) found that lumping these ethnic subgroups together obscures notable differences. Alternatively, Puerto Ricans actually displayed a higher overdose death rate than White Americans in 2017 (Cano, 2020). Research also shows that, "From 2015 to 2017, African Americans in metro areas experienced the largest absolute and percentage increases in drug overdose deaths from opioids when compared to other race/ethnicities" (Stevens-Watkins, 2020, p. 857). Further, evidence suggests that Black opioid-related overdose deaths are growing nationally at a rate that now outpaces White deaths (Furr-Holden et al., 2021).

The evolution of the opioid epidemic may also feature shifts in deaths by gender. In the current epidemic, gender differences in overdose death rates align with the changes in the types of drugs involved in overdose deaths and the gendered nature of their use (Ho, 2020). While female deaths were largely attributable to prescription opioids from 1999 to 2017 (Campbell et al., 2010; Ho, 2020), male deaths more often resulted from illegal drugs and polydrug use through the same period (Eeckhaut et al., 2020; Ho, 2020). In turn, mortality trends changed with the types of drugs contributing to the problem. As prescription opioids took hold, the share of women among overdose decedents increased and converged with the number of male decedents—owing to a number of factors including higher levels of prescription use and healthcare utilization (Ho, 2020). However, the transition to illegal drugs and the impact of fentanyl has once again widened the gender gap. This national level pattern is confirmed at the state level in Delaware, as investigators find that drugs like fentanyl and heroin drove a substantial increase among men from 2013 to 2017 (Eeckhaut et al., 2020). While women still experienced a high rate of

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overdose death from prescription drugs, the increase among men driven by fentanyl was much more dramatic.

The spread of fentanyl & opioid-stimulant deaths

These increases among the Black and Hispanic population appear tied to the spread of fentanyl and other synthetic opioids, as well as a general rise in polydrug use. Specifically, the rise in stimulant-related overdose deaths is likely due to the "simultaneous presence of fentanyl, either added directly to the drug supply or used concomitantly" (LaRue et al., 2019, p. 5; [also see Jones et al. (2020)]). On the one hand, illicitly manufactured fentanyl is frequently used by drug distributors to alter drugs like heroin and cocaine without the buyer's knowledge or to make counterfeit prescription pills (Alexander et al., 2017; Mars et al., 2019; Rothberg & Stith, 2018) and studies find that Black Americans may be especially at risk for fentanyl-tainted heroin and other drugs (Rigg & Nicholson, 2019; Ray et al., 2020). Additionally, Cano (2020) finds that synthetic opioids such as fentanyl were implicated in 40.2 percent of all Hispanic deaths, representing the most common substance involved in overdose deaths for all ethnic subgroups except for those of Mexican descent.

On the other hand, although it is widely reported that fentanyl-laced drugs are a significant problem, the observed trends in polydrug toxicology may represent more intentional forms of polydrug use. During prior opioid problems in the 1960s and 1970s, the injection of "speedballs"—a heroin and cocaine mixture—was common among heroin users and those in methadone treatment often tested positive for cocaine, and some studies also revealed combined heroin and methamphetamine use which is referred to as a "goofball" (Leri et al., 2003; Inciardi & Harrison, 1998; Chitwood et al., 1998; Hunt et al., 1984; Strug et al., 1985). Researchers have documented numerous reasons for combined cocaine and opioid use including injecting a mixture for a more euphoric experience or using cocaine as a self-medication to gradually reduce heroin use and eliminate opioid dependence (Inciardi & Harrison, 1998; Kreek, 1997; Hunt et al., 1984; Ellinwood et al., 1976).

Combined opioid-stimulant use has returned and now defines a fourth-wave of the opioid epidemic (Ciccarone, 2021; Jenkins, 2021). Research finds opioid-stimulant combinations vary by region in overdose deaths. Opioid-methamphetamine combinations are concentrated in the Southern, Western, and Midwestern regions of the United States (Ellis et al., 2018; Jones et al., 2020; also see Lockwood et al., [2021] study of Marion County, Indiana) while opioid-cocaine deaths are concentrated in the Northeast (Kariisa et al., 2019). To date, however, there is less information on how

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such fourth-wave deaths might vary by race and gender. Understanding such variations is necessary for tailoring intervention efforts aimed at reducing the problem and reducing inequalities stemming from racialized and gendered responses to drug problems. And while national-level analyses are important, state and local investigations may be more suited to evaluate how groups are being impacted relative to their community contexts (James & Jordan, 2018). The purpose of our paper is to investigate the rise of stimulants in overdose death toxicology reports between 2013 and 2019 in Delaware, which can serve as a microcosm of the problem, and how combined opioid-stimulant overdose deaths may be patterned by race and gender.

Delaware as the site of investigation

While Delaware is the second smallest state in the nation, its consistently high overdose death rate and recent inclusion in the Drug Enforcement Administration's (DEA) High Intensity Drug Trafficking Areas' (HIDTA) Liberty Mid-Atlantic region make it a useful focal point to investigate the latest trends in the opioid epidemic (DEA, 2020a; Scholl et al., 2019). Specifically, Delaware and its neighbor state of Pennsylvania have ranked in the top ten states for overdose death rates since 2016 (Seth et al., 2018) and fell just under that mark in the earlier years (2013–2015) of our study. In fact, similar trends have been recorded throughout the Mid-Atlantic region and across the Eastern seaboard (Segel & Winkelman, 2021). Delaware moved into the CDC's top ten list around 2016 and about the time the DEA reported a significant increase in cocaine availability in the region (DEA, 2020b). Further, while some states saw overdose death rates decline between 2017 and 2018, Delaware was one of the five states that had a higher rate in 2018 than 2017 and, in fact, had the second highest rate in 2018 overall based on data from the National Vital Statistics System [NVSS] (Hedegaard et al., 2020). Within the Liberty Mid-Atlantic area, the DEA has estimated that illicit opioids (i.e., heroin, fentanyl) comprise 41.0% of the drug market, followed by cocaine (29.0%), Rx opioids (16.0%), and methamphetamines (6.5%). Additionally, the DEA estimates that nearly all of today's heroin flowing into Delaware and the Liberty Mid-Atlantic region is fentanyl-tainted (DEA, 2020a).

Data and methods

Data source

Our study is based on toxicology data from *all* drug overdose deaths in Delaware between 2013 and 2019 provided by the Delaware Division of

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Forensic Science (DFS). Medical examiners conduct death investigations and supplement them with toxicology reports when drugs are suspected as a cause of death. The Toxicology Unit utilizes enzyme-linked immunosorbent assay (ELISA) to screen for drugs preliminarily while distinguishing between twelve drug classes: amphetamines, barbiturates, benzodiazepines, cannabinoids, carisoprodol, cocaine, fentanyl, methadone, methamphetamine, opioids, oxycodone, and phencyclidine (PCP). After this screening, gas chromatography-mass spectrometry (GC-MS) is used to confirm positive results by testing peripheral blood specimens, but also sometimes through the testing of other bodily specimens (e.g., bile, urine, skeletal muscle, liver). Overdose death cases are then coded based on confirmation tests and the IBM Micromedex RED BOOK to assign therapeutic class. Thus, each death is coded according to the types of drugs present in a decedent's system. Importantly, the toxicology reports include *all* drugs in a decedent's system at the time of death. Our analysis shows important trends from 2013 to 2019 regarding the presence of the six most common drug-types found: benzodiazepines, cocaine, fentanyl, heroin, prescription (Rx) opioids, and a category including "other" stimulants (i.e., methamphetamine, amphetamine, phenethylamine, methylphenidate, phentermine, phenmetrazine, phendimetrazine, ritalinic acid).

The DFS overdose toxicology data also include demographic information for decedents, such as age, gender, and race/ethnicity. We choose to focus on gender and race/ethnicity here to show differential trends across these groups. We rely on the DFS's racial/ethnic designations which are determined during the forensic science investigation, which includes reviewing case documents, family information, and other statewide databases. Of Delaware's 2019 estimated population of 973,764 residents, 62.0% were White (non-Hispanic), 23.0% Black (non-Hispanic), and 10.0% Hispanic/Latino. The remaining portion of the state's population is split primarily between Asian/Pacific Islanders and Native Americans; however, we do not examine these groups due to their low representation in the overdose death data.

For our analysis, we consider both total and demographic group-specific (i.e., race/ethnicity and gender pairings) rates at which certain drugs are found in toxicology reports. That is, regarding patterns of opioid- and stimulant-involvement, we focus on Black (non-Hispanic), White (non-Hispanic), and Hispanic/Latino residents, as well as males and females separately across these racial/ethnic groups. Notably, when it comes to stimulant involvement, we examine cocaine separate from "other stimulants" given the prevalence of cocaine in Delaware overdose deaths (34.4% of all decedent toxicology reports from 2013–2019) and lower rates of methamphetamines, amphetamines, and other substances classified as stimulants

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("other" stimulants combined only appear in 14.1% of decedent toxicology reports from 2013–2019) relative to other regions of the United States. We also investigate the combined presence of the three most common drugs present in Delaware's overdose deaths—heroin, fentanyl, and cocaine. We focus on these three substances given their dominance in Delaware's drug markets and decedent toxicology reports, our research objectives, and findings from other studies showing the increasing presence of both opioids and stimulants elsewhere in the US (Barocas et al., 2019; Gladden et al., 2019; Hoots et al., 2020; O'Donnell et al., 2020). This investigation allows us to provide answers to questions about the relationship between different opioids and stimulants present in a decedent's system at death. Further, these drug categories are not mutually exclusive since decedents often test positive for multiple substances. Ultimately, the yearly trends for single and polydrug overdose deaths are documented across these race/ethnicity- and gender-specific demographic groupings.

Analytic technique

We constructed crude rates of positive toxicology for the six most frequently reported drug-types and considered the change in these rates across the years under study and among specific demographic groups. We examined all cases in Delaware where a death was reported to have been caused by drugs and include only those decedents with home addresses located within state boundaries (N = 1,871). Notably, 259 or about 12.2% of decedents were excluded from our study because their home addresses were outside of the state. On average, such exclusions approximated 11.5% of overdose deaths per year, ranging from a low of 7.3% (17 deaths) in 2015 to a high of 18.3% (56 deaths) in 2016.

Annual rates reported were constructed using the yearly *National Center for Health Statistics Bridged-Race Population Estimates* (2013–2019) of the July 1st resident population (Centers for Disease Control and Prevention [CDC], 2020). The estimates obtained included the total Delaware population per year and the yearly race/ethnicity- and gender-specific population breakdowns. Thus, crude toxicology rates were specific to demographic groups and were standardized per 100,000 Delaware residents. Notably, the Black male population total did not reach 100,000 per year until 2016 and the total Hispanic/Latino population never exceeded 100,000 for any year.

Figure 1 illustrates notable demographic trends in overdose deaths across race/ethnicity and gender. First, White males reported the highest overdose death rates for all years studied. Second, White females reported the second highest overdose death rates between 2013 and 2015 but were then

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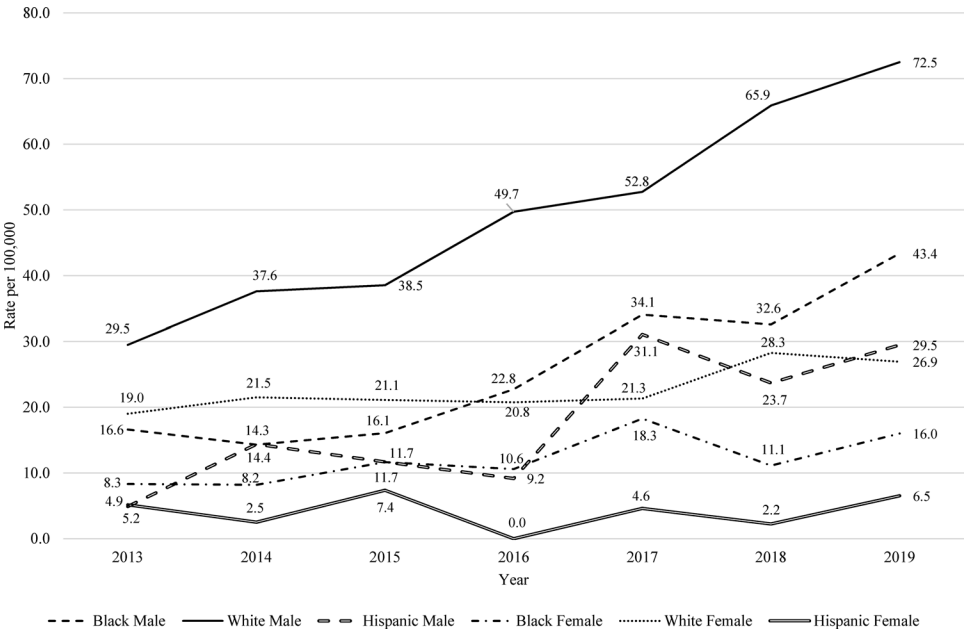

Figure 1. Overdose decedent trends by race/ethnicity and gender in Delaware.

surpassed by Black and Hispanic males in 2016 to 2019. Third, since 2016, male overdose deaths have consistently outpaced females' death rates regardless of race and ethnicity. The findings below report on both single and combined drug toxicologies of these groups over time.

We also focus on separate combinations of the three substances most present among Delaware decedents: *cocaine and heroin* (13.6%), *cocaine and fentanyl* (20.7%), *fentanyl and heroin* (21.6%), and *cocaine, fentanyl, and heroin* (9.0%). Importantly, these groups are not mutually exclusive, which is demonstrated by the combination of *fentanyl, cocaine, and heroin*, and other unaccounted for drug-types (e.g., benzodiazepines) may have also appeared in decedents' toxicology reports. Given the prevalence of these substances in Delaware and growing concerns with polydrug use, we conclude our results by examining trends in combined substance use and its patterning across different demographic groups annually.

Besides yearly rates, we also consider the *Growth Rates* in positive toxicology for specific drug types and drug combinations over time across demographic groups. For these calculations, the following formula is used:

$$Growth\ Rates(\%) = \frac{\left[\left(\frac{Time\,2\ Rate - Time\,1\ Rate}{Time\,1\ Rate}\right) \times 100\right]}{Number\ of\ Years} \quad (1)$$

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Table 1. Drug toxicology growth rates in overdose decedents by race/ethnicity and gender, 2013–2019[1,2].

	Individual drug-type growth rates[3]					
	Black male	Black female	Hispanic male	Hispanic female	White male	White female
Heroin	32.4	79.4	70.3	N/A[†]	21.0	23.0
Fentanyl	117.3	160.3	78.5*	9.9	223.7	167.0
Rx Opioids	13.3	19.9	70.3	−2.0*	1.2	−2.1
Cocaine	39.3	24.7	100.7*	−2.2	71.4	24.6
Other Stimulants	120.0	55.6*	20.7*	N/A	40.6	36.1
Benzodiazepines	11.6	52.4	19.8	N/A[†]	4.7	2.4
	Drug Combination Growth Rates					
	Black male	Black female	Hispanic male	Hispanic female	White male	White female
Cocaine & Heroin	33.6	66.7	27.1*	N/A	62.2	16.7
Cocaine & Fentanyl	308.6	52.8*	135.9*	−2.2	344.3	150.0*
Fentanyl & Heroin	228.6	138.9*	55.4*	N/A	87.7*	56.4*
Cocaine, Fentanyl, & Heroin	134.3	5.3*	43.5*	N/A	200.0*	55.6*

[1]N = 1,871 overdose decedents from 2013-2019 in Delaware; Black males = 184; Black females = 96; Hispanic males = 56; Hispanic females = 12; White males = 1,018; White females = 498.
[2]Growth Rates are not mutually exclusive as decedents may have had positive tests in their toxicology reports for multiple substances.
[3]The Growth Rate is calculated as the average yearly Growth Rate (%) between 2013 and 2019.
[4]"N/A" indicates that the Growth Rate could not be calculated based on the available data reported and yearly rates that had been calculated.
*These Growth Rates are not calculated for the total 2013-2019 timespan. When a "0" is the value for the first year the Growth Rate cannot be calculated including that year.
[†]There were "0" heroin- or benzodiazepine-related deaths for Hispanic females in 2019.

This equation gives the percentage increase or decrease in the overdose death toxicology rate from 2013 to 2019 where *Time 2* corresponds to the 2019 rate while *Time 1* is the earliest rate available in the 2013-2019 timeframe. The calculated change value is then divided by the number of years this calculation spans. Thus, some Growth Rates in the tables do not capture the full 7-year period due to the presence of "0" decedents

Table 2. Cocaine, fentanyl, and heroin toxicology for overdose decedents in Delaware: frequency and percentages.

	Number of cocaine, fentanyl or heroin positives in decedent toxicology reports[1]		
Year	1[2]	2	3
2013 (N = 174)	66 (37.9%)	14 (8.0%)	1 (0.6%)
2014 (N = 208)	85 (40.9)	32 (15.4)	3 (1.4)
2015 (N = 217)	99 (45.6)	31 (14.3)	2 (0.9)
2016 (N = 250)	100 (40.0)	69 (27.6)	14 (5.6)
2017 (N = 297)	103 (34.7)	120 (40.4)	43 (14.5)
2018 (N = 343)	119 (34.7)	128 (37.3)	54 (15.7)
2019 (N = 382)	151 (39.5)	146 (38.2)	52 (13.6)
Totals (N = 1,871)	723 (38.6)	540 (28.9)	169 (9.0)

N = 1,871 Delawarean Overdose Decedents.
[1]There are 439 (23.5%) cases where neither cocaine, fentanyl, nor heroin were present in the decedent's toxicology report. Included in these cases are 28 (1.5% of total cases) decedents with "missing" toxicology confirmations.
[2]The "1" column indicates only one of these three substances was positive, "2" corresponds to two being positive, and "3" provides the totals where all three substances were positive.

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for some demographic groups in certain years since the calculation cannot be completed when the *Time 1 Rate* is a "0" value.

Finally, our interest in this manuscript lies in examining demographic trends, which makes this inquiry descriptive in nature. Additionally, the toxicology reports we examine include the total population of overdose deaths in the state of Delaware. Given the descriptive nature of our analysis and the fact we are studying a total population, the calculation of confidence intervals or significance tests is not necessary for our investigation ([Berk et al., 1995; Cowger, 1984; Rubin, 1985]; also see Eeckhaut et al., [2020] for a similar analysis of gender trends in opioid deaths).

Results

Trends in overdose death toxicology

Overdose deaths in Delaware, as in most of the nation, have risen dramatically throughout the opioid epidemic (DEA, 2020 b; Eeckhaut et al., 2020; Hedegaard et al., 2020). To reiterate points from above, overdose death trends across the nation show decreased involvement of Rx opioids and an increase in synthetic opioids such as fentanyl (Eeckhaut et al., 2020; Hedegaard et al., 2020). Additionally, toxicological reporting shows stimulants have become more prominent in overdose deaths across the country (Hedegaard et al., 2021; Jones et al., 2017; Jones et al., 2020). Our analysis of data in Delaware shows consistency with the regional and national picture. However, we also find important variations, especially recently and across demographic groups that could serve as a warning of what may be to come for the Mid-Atlantic region and beyond.

We begin with Figure 2, which shows trends in positive toxicology for specific drugs between the years of 2013 and 2019. Fentanyl, cocaine, and heroin were most often present in overdose deaths, in that order, respectively. The rate of fentanyl involvement in overdose deaths rose from 2.4 per 100,000 in 2013 to 33.0 per 100,000 in 2019. Next, the rate of cocaine involvement increased from 3.8 per 100,000 to 16.5 per 100,000 during the same period. The rate of heroin involvement increased from 4.3 per 100,000 in 2013 to 12.0 per 100,000 in 2019. Additionally, the rate of overdose deaths involving Rx opioids rose slightly from 11.4 per 100,000 in 2013 to 13.4 per 100,000 in 2019. The presence of "other" stimulants in overdose deaths increased from 2.2 per 100,000 to 9.3 per 100,000 during our study period, staying well below rates of cocaine. Benzodiazepines were present at rates of 6.6 per 100,000 in 2013 and 9.0 per 100,00 in 2019. In sum, Figure 2 highlights the increasing prevalence of non-Rx opioids and stimulants, especially cocaine, in overdose deaths in Delaware over the seven-year period.

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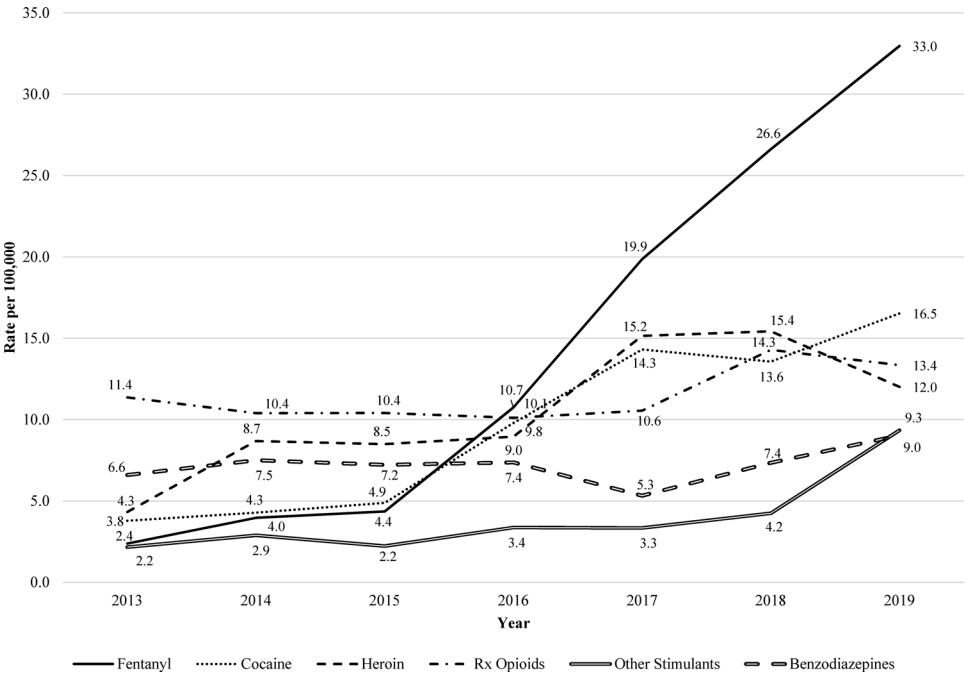

Figure 2. Positive toxicology in overdose decedents by drug-type in Delaware.

Drug toxicology by demographic group

In further consideration of our first research question, we explored growth rates in drugs reported in toxicological screenings of decedents in these groups between 2013 and 2019. Table 1 illustrates these growth rates for individual drug types. While the positive toxicology growth rates for White male and female Delawareans are elevated across drug types, the increased growth rates of other demographic groups are notable as well. For example, the largest rate changes over the seven-year period include: fentanyl for White males (223.7%), White females (167.0%), Black females (160.3%), Black males (117.3%), and Hispanic males (78.5%); cocaine for Hispanic males (100.7%), White males (71.4%), Black males (39.3%), and White females (24.6%); heroin for Black females (79.4%), Hispanic males (70.3%), and Black males (32.4%); "other" stimulants for Black males (120.0%); and benzodiazepines for Black females (52.4%). Growth rates for Hispanic females were consistently the lowest among the groups studied though the growth in fentanyl presence (9.9%) is notable among this population. In sum, the results illustrated in Table 1 and Figure 2 highlight the consistent growth rate in drugs reported in toxicology screenings of overdose decedents across the seven-year period. Yet, these growth rates varied by demographic group and drug, with White males showing the highest growth in fentanyl toxicology, Hispanic males for cocaine toxicology, and Black females for heroin toxicology.

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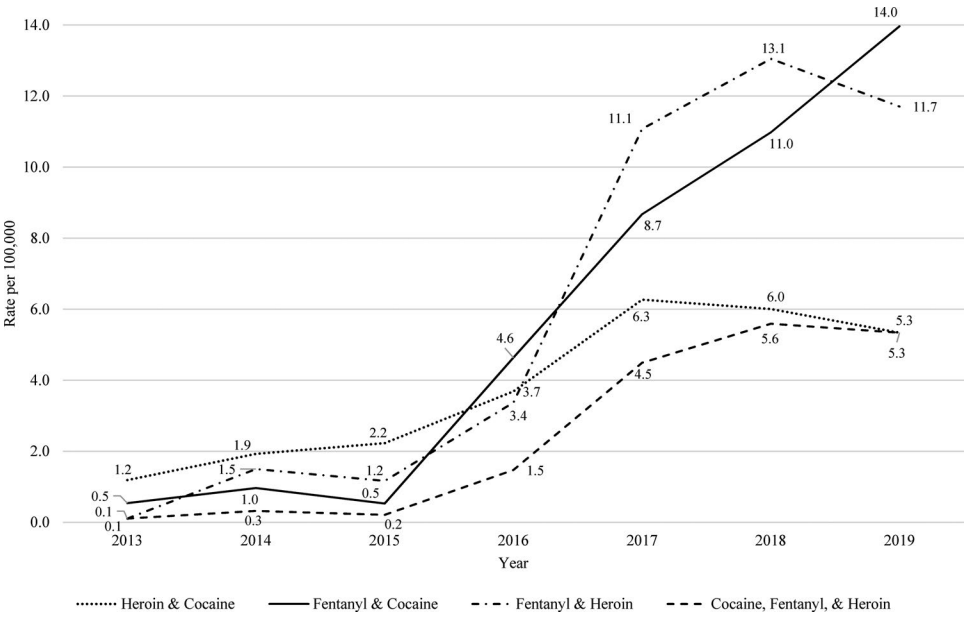

Figure 3. Positive toxicology in overdose decedents by drug combinations in Delaware.

Drug combinations

Figure 3 and Table 1's lower portion on drug combinations address our second research question about the growth in drug combinations, specifically opioids and cocaine. Figure 3 indicates that beginning in 2016, there was a steady increase in polydrug drug reports among overdose decedents. By 2019, the most prevalent drug combination reported in overdose decedents was *cocaine and fentanyl*. This combination exhibited a nearly four-fold increase between 2016 (4.6 per 100,000) and 2019 (14.0 per 100,000). By 2019, the second most prevalent drug combination reported was *fentanyl and heroin*. This drug combination demonstrated a nearly quadrupled increase between 2016 (3.4 per 100,000) and 2019 (11.7 per 100,000)—though this combination peaked in 2018 (13.1 per 100,000). *Cocaine and heroin* and the combination of *cocaine, fentanyl, and heroin* were of equal presence in 2019 toxicology reports (5.3 per 100,000) illustrating the level of overlap among these three drugs. The combination of *cocaine and heroin* indicated a nearly two-fold increase between 2016 (3.7 per 100,000) and 2019 (5.3 per 100,000) with a peak of 6.3 per 100,000 in 2017. Finally, by 2019, *cocaine, fentanyl, and heroin* were all reported in 5.3 per 100,000 overdose decedents. This represents an almost five-fold increase since 2016.

These trends illustrate the increasing prevalence of polydrug positivity in overdose decedents in Delaware, particularly between 2016 and 2019. Specifically, this shift in overdose death trends toward greater polydrug

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positivity was driven primarily by cocaine and non-Rx opioids. This transition is further indicated in Table 2 which shows the increasing presence of both stimulants and non-Rx opioids, respectively, and also polydrug positivity in overdose decedents beginning around 2016 and continuing through 2019. Further, the combined presence of *cocaine and fentanyl* was the only polydrug combination that did not plateau or decline by 2019 suggesting an especially concerning trend in the use of these two substances.

Drug combinations by demographic group

Table 1 also captures the growth rates in polydrug positivity reported for overdose decedents across race/ethnicity and gender groups. Specifically, the growth rate in *cocaine and heroin* positivity was highest for Black females (66.7%), second highest for White males (62.2%), third highest for Black males (33.6%), fourth highest for Hispanic males (27.1%), and White females (16.7%) had the lowest growth rate for this combination. On the other hand, the growth rate in *cocaine and fentanyl* positivity for White males (344.3%) was highest followed closely by Black males (308.6%). The third highest growth rate for *cocaine and fentanyl* is found among White females (150.0%), which is higher than the growth rates for Hispanic males (135.9%) and Black females (52.8%) while Hispanic females (-2.2%) were the only group to have fewer cases by 2019. For *fentanyl and heroin* positivity, the growth rate for Black male (228.6%) and female (138.9%) overdose decedents was higher than the growth rate for White males (87.7%), White females (56.4%), and Hispanic males (55.4%). Finally, for *cocaine, fentanyl, and heroin* positivity, the growth rates for White males (200.0%) and Black males (134.3%) were higher than the growth rates for White females (55.6%), Hispanic males (43.5%), and Black females (5.3%).

In sum, Figure 3 and the lower portion of Table 1 illustrate the increasing growth rates of polydrug toxicology in overdose decedents between 2013 and 2019. Additionally, these data indicate that polydrug growth rates for White males were highest for two out of the four drug combinations–*cocaine and fentanyl* and *cocaine, fentanyl, and heroin* toxicology, respectively. On the other hand, Black females had the highest growth rate for *cocaine and heroin* while Black males had the highest growth rate for *fentanyl and heroin*.

The race/ethnicity and gender trends in positive polydrug toxicology in overdose decedents is further illustrated in Figures 4, 5, 6, and 7. Figure 4 captures *cocaine and heroin* toxicology between 2013 and 2019 by race/

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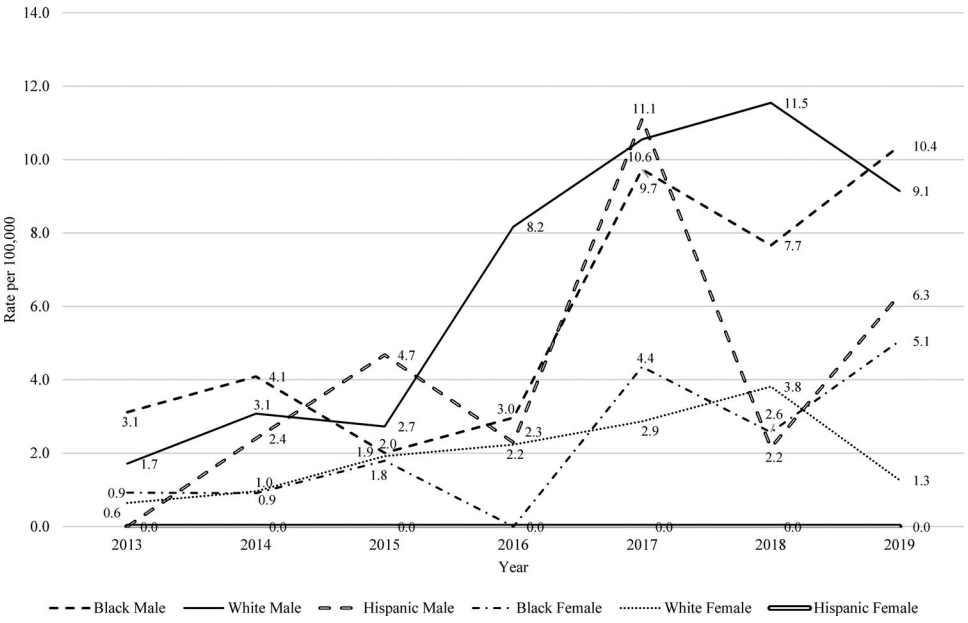

Figure 4. Positive cocaine & heroin combined toxicology in overdose decedents in Delaware.

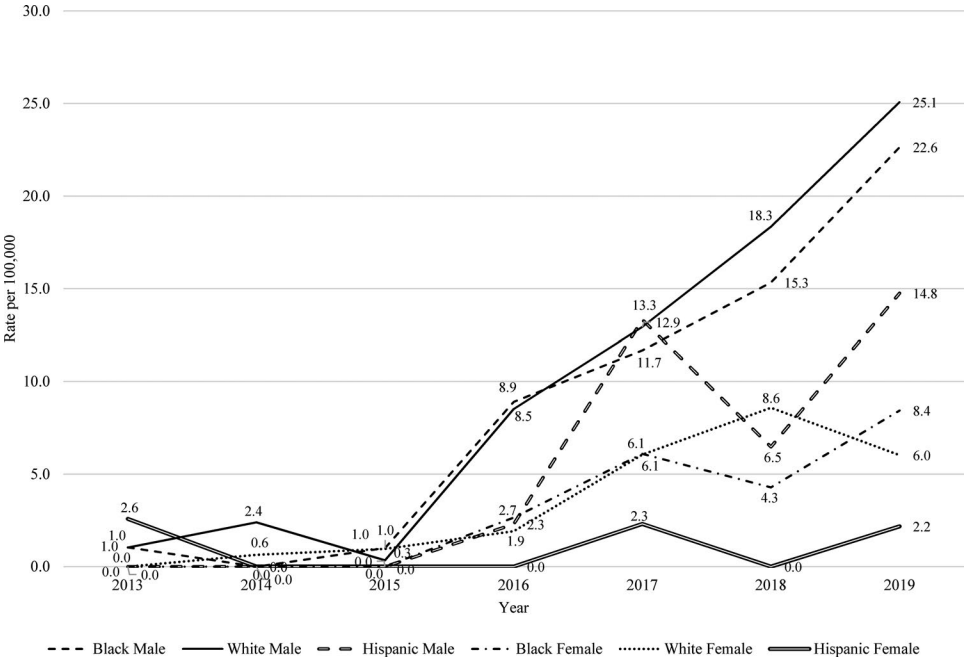

Figure 5. Positive cocaine & fentanyl combined toxicology in overdose decedents in DE.

ethnicity and gender. White male overdose decedents exhibited a five-fold increase (1.7 per 100,000 in 2013 to 9.1 per 100,000 in 2019)—though this combination was more prevalent in 2017 and peaked in 2018 among

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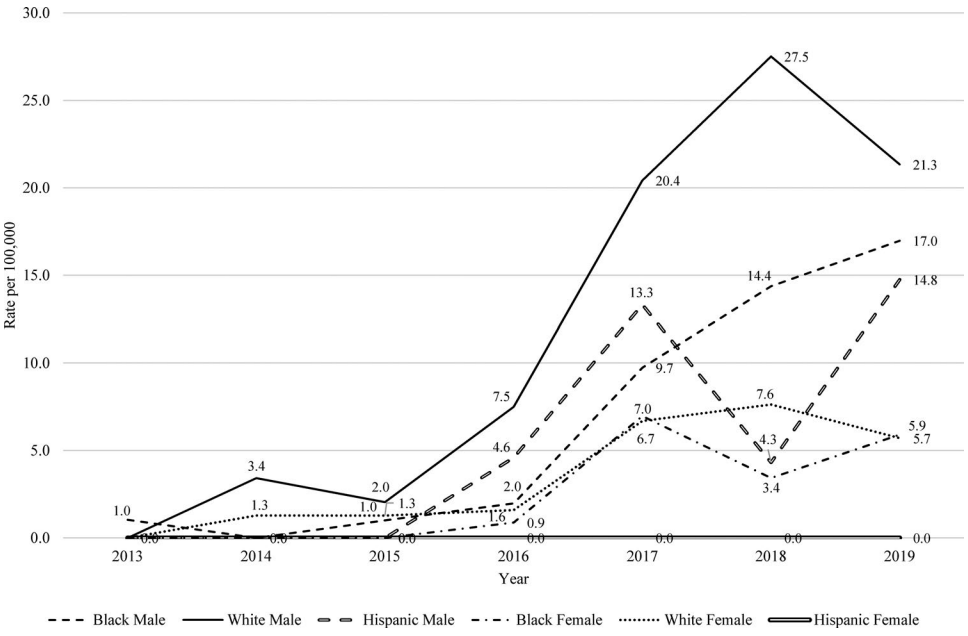

Figure 6. Positive fentanyl & heroin combined toxicology in overdose decedents in Delaware.

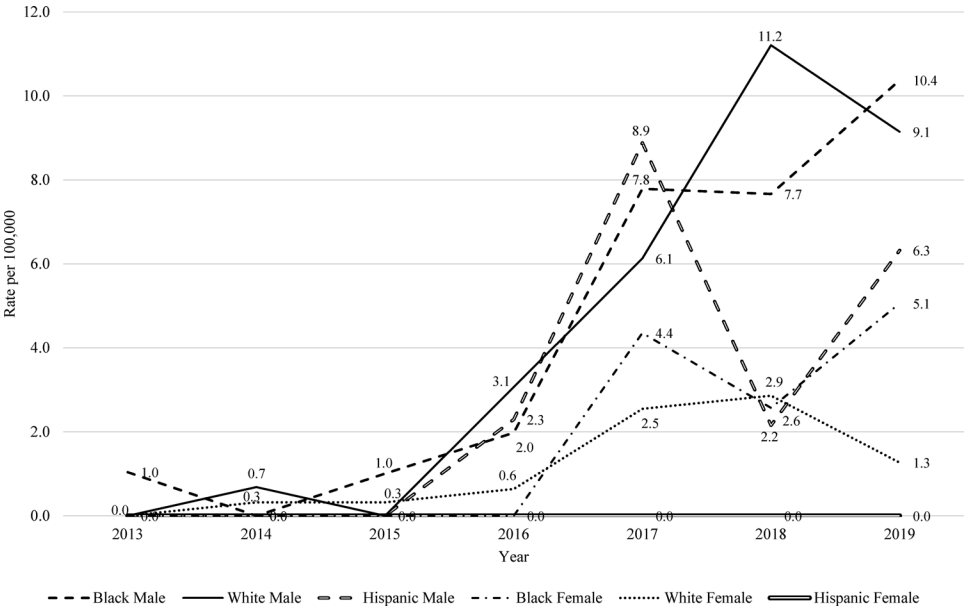

Figure 7. Positive cocaine, fentanyl, & heroin combined toxicology in overdose decedents in Delaware.

White males. Black male overdose decedents tripled from 2013 to 2019 (3.1 per 100,000 to 10.4 per 100,000, respectively), reaching a peak in 2019 after a slight decline from 2017 to 2018. Hispanic male overdose

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decedents demonstrated a six-fold increase (0.0 per 100,000 in 2013 to 6.3 per 100,000 in 2019) though they peaked at a higher rate (11.1 per 100,000) in 2017 before a steep decline in 2018 (2.2 per 100,000). White female overdose decedents also saw an increase (0.6 per 100,000 in 2013 to 1.3 per 100,000 in 2019) though there was a peak in 2018 (3.8 per 100,000). Black female overdose decedents demonstrated a six-fold increase (0.9 per 100,000 in 2013 to 5.1 per 100,000 in 2019). For Hispanic females, *cocaine and heroin* combined toxicology remained 0.0 per 100,000 for all years under study. Overall, Figure 4 indicates that Black males, Hispanic males, and Black females all exhibited increases in *cocaine and heroin* toxicology by 2019. On the other hand, while White males and females also saw generally increasing rates of this combination over the years considered, they both saw declines from 2018 to 2019.

Figure 5 highlights *cocaine and fentanyl* toxicology between 2013 and 2019 by race/ethnicity and gender. Notably, the presence of *cocaine and fentanyl* toxicology in overdose decedents is relatively non-existent until 2016. Beginning that year, *cocaine and fentanyl* toxicology in White male overdose decedents increased from 8.5 per 100,000 to 25.1 per 100,000 in 2019. For Black male overdose decedents, *cocaine and fentanyl* toxicology increased from 8.9 per 100,000 in 2016 to 22.6 per 100,000 in 2019. For Hispanic male overdose decedents, *cocaine and fentanyl* toxicology increased from 2.3 per 100,000 in 2016 to 14.8 per 100,000 in 2019, but there was a decline from 2017 (13.3 per 100,000) to 2018 (6.5 per 100,000). For White female overdose decedents, *cocaine and fentanyl* toxicology increased from 1.9 per 100,000 in 2016 to 6.0 per 100,000 in 2019 though there was a peak in 2018 (8.6 per 100,000). For Black female overdose decedents, *cocaine and fentanyl* toxicology increased from 2.7 per 100,000 in 2016 to 8.4 per 100,000 in 2019. Finally, for Hispanic female overdose decedents, *cocaine and fentanyl* toxicology increased from 0.0 per 100,000 in 2016 to 2.2per 100,000 in 2019; though 2017 was higher (2.3 per 100,000) and 2018 had a 0.0 rate per 100,000. Overall, White males and Black males were the only two groups that experienced consistently increasing *cocaine and fentanyl* toxicology across the years considered. Additionally, Hispanic males, Black females, and Hispanic females all had higher rates by 2019 while White females saw consistent increases overall besides a slight decline from 2018 to 2019.

Figure 6 explores trends in positive *fentanyl and heroin* combined toxicology for overdose decedents between 2013 and 2019. For White male overdose decedents, this polydrug toxicology increased from 0.0 per 100,000 in 2013 to 21.3 per 100,000 in 2019 though there was a peak in 2018 (27.5 per 100,000). For Black male overdose decedents, the presence of this polydrug toxicology increased from 1.0 per 100,000 in 2013 to

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17.0 per 100,000 in 2019. For Hispanic male overdose decedents, this polydrug toxicology increased from 0.0 per 100,000 in 2013 to 14.8 per 100,000 in 2019 though there was a steep decline from 2017 to 2018 before the peak in 2019. For White and Black female overdose decedents, this polydrug toxicology increased from 0.0 per 100,000 in 2013 to 5.7 per 100,000 in 2019 and 0.0 per 100,000 in 2013 to 5.9 per 100,000, respectively. Both White and Black females had higher rates in the years before 2019–White females had a rate of 6.7 in 2017 and 7.6 in 2018 while Black females peaked at 7.0 in 2017. Finally, for Hispanic female overdose decedents, there were no cases of combined *fentanyl and heroin* toxicology from 2013 to 2019.

In sum, White males and Black males exhibited the highest increase in *fentanyl and heroin* toxicology between 2013 and 2019–though White males did see a decline in cases from 2018 to 2019. Moreover, Figure 6 indicates that the presence of *fentanyl and heroin* in overdose decedents was fairly stable between 2013 and 2016. Then, beginning in 2016, decedents of all genders and racial/ethnic groups, with the exception of Hispanic females, exhibited exponential increases in positive *fentanyl and heroin* combined toxicology.

Lastly, Figure 7 illustrates the trends in positive *cocaine, fentanyl, and heroin* combined toxicology in overdose decedents between 2013 and 2019. Similar to other combinations, the presence of *cocaine, fentanyl, and heroin* in overdose decedents was relatively non-existent until 2016. Beginning that year, with the exception of Hispanic females, all other demographic and gender groups exhibited increases in polydrug toxicology. For White male overdose decedents, their polydrug toxicology increased from 3.1 per 100,000 in 2016 to a peak of 11.2 per 100,000 in 2018 and a slight decline to 9.1 per 100,000 in 2019. For Black male overdose decedents, their polydrug toxicology increased dramatically from 2.0 per 100,000 in 2016 to 7.8 per 100,000 in 2017–surpassing the rate among White males–and then stayed consistent in 2018 (7.7 per 100,000) before increasing again in 2019 (10.4 per 100,000) where they have the highest rate of all demographic groups considered. For Hispanic male overdose decedents, their polydrug toxicology increased from 2.3 per 100,000 in 2016 to 6.3 per 100,000 in 2019; however, there was a sharper increase from 2016 to 2017 (8.9 per 100,000)—even outpacing Black and White males–before a sharp decline in 2018 (2.2 per 100,000). For White female overdose decedents, their polydrug toxicology increased from 0.6 per 100,000 in 2016 to 1.3 per 100,000 in 2019 though the rate was higher in 2017 (2.5 per 100,000) and 2018 (2.9 per 100,000). And for Black female overdose decedents, their polydrug toxicology increased from 0.0 per 100,000 in 2016 to 5.1 per 100,000 in 2019 where they outpaced White females and

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nearly reached a similar rate to Hispanic males that year. Hispanic female decedents did not have any cases of all three substances being present in their toxicology reports. In sum, Figure 7 indicates that all groups besides Hispanic females saw increasing polydrug use; however, Black males were the group to see the most consistent rate increases while other groups saw more fluctuation including White males and females actually having lower rates in 2019 than the previous year.

Discussion

In this study, we investigated changes in drug overdose decedent toxicology by demographic group since the opioid epidemic shows little sign of ending and has entered a fourth-wave (Ciccarone, 2021; Jenkins, 2021). Using 2013 to 2019 overdose death toxicology data in Delaware—a state among the highest in the nation for overdose deaths and a key part of a HIDTA region tracked by the DEA—we found that fentanyl has become the most prominent drug in overdose deaths, as it is in much of the nation. However, our study also shows the substantial rise of cocaine and cocaine-fentanyl and cocaine-heroin combinations in decedent toxicology between 2013 and 2019. Even more troubling, perhaps, was the combined presence of all three drugs—fentanyl, heroin, and cocaine—in Delaware's 2019 deaths. There were three other common themes. First, polydrug toxicology in overdose decedents was relatively low and/or non-existent between 2013 and 2016. Second, beginning in 2016 and continuing through 2019, Delaware overdose decedents increasingly exhibited positive toxicology for drug combinations. Third, between the years of 2014 and 2015, overdose death rates worsened among demographic groups that had previously displayed relatively low rates compared to Whites.

Our study also shows that all demographic groups have experienced an escalation in drug toxicology over time and are susceptible to fentanyl- or heroin-cocaine combinations. Males show the largest absolute rates of combined fentanyl, heroin, and cocaine toxicology. Between 2013 and 2016, reported combined toxicology rates were relatively low among all groups. However, this changed in 2016 as all groups started to see rising rates with both Black and Hispanic males even surpassing White males in 2017 and Black males having the highest rate of combined *cocaine, fentanyl, and heroin* toxicology overall in 2019. Hispanic females were the only group to consistently show little evidence of polydrug use across the years examined. These developments call attention to the necessity of attending to race-gender variations in overdose deaths and warrant additional study.

These findings are also remarkable considering that combined *cocaine and fentanyl* positivity in overdose decedent toxicology was modest in

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2013 and has increased six-fold just since 2016, a year when the DEA (2020a, 2020b) documented a major increase in cocaine availability in the region's illicit drug markets. While overdose deaths involving "other" stimulants, including methamphetamine, also modestly increased during our study period, cocaine is currently more problematic in Delaware's overdose deaths, raising concerns about cocaine positivity in other states in the Mid-Atlantic region. Yet, although the DEA's (2020b) report on Pennsylvania—another state that is part of the HIDTA Liberty Mid-Atlantic region—shows a rapid escalation in methamphetamine seizures and overdose toxicology *statewide*, not just in Philadelphia, Delaware's modest increase in methamphetamine and other stimulants is generally consistent with regional trends in methamphetamine use (Ellis et al., 2018; Jones et al., 2020). Thus, combined stimulant-opioid use may be a new reality that varies geographically, even within a given state.

Our findings indicate additional troubling trends. For example, today's overdose decedents may be more involved with illicit drugs than those from earlier years of the opioid epidemic, as indicated by the increases in heroin, cocaine, and fentanyl toxicology. The rise of polydrug toxicology in overdose deaths can be explained by the use of fentanyl as a supply-side adulterant to many drugs or asa potential trend of risky drug use practices, such as intentional mixing of substances (Mars et al., 2019). Future research should investigate the current state of drug markets and contemporary drug-use practices to better understand this trend.

Finally, the demographic trends observed in our study highlight the increase in overdose deaths among communities that had been less severely affected in earlier stages of the epidemic. For instance, Black males' overdose death rates increased substantially to become the second-highest rate by 2019 in Delaware, which aligns with national studies showing that the growth in opioid-related overdose deaths among African Americans now outpaces White overdoses (Furr-Holden et al., 2021)—a trend that continued during the COVID-19 pandemic (Friedman & Hansen, 2021). In a more variable upward trend, Hispanic males' overdose death rate also increased over the course of our study. Although the trend among Hispanic males is generally consistent with national patterns and the increasing impact of fentanyl beginning in 2015 (Cano, 2020), yearly fluctuations in overdose death rate may be a product of (1) local variations in drug markets not captured by our data or (2) the susceptibility of rates to small changes given the relatively low numbers of Hispanics in the study population, especially when calculating rates for combined drug toxicology. In any case, our findings support the notion of considerable gender variation in overdose deaths across demographic groups. For instance, Hispanic females displayed no meaningful increase in overdose death rate and were

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consistently the lowest rates among all groups. Additionally, although Black females' overdose death rates nearly doubled over the study period, their rate in 2019 was still less than half of their male counterparts. Nonetheless, White females have displayed consistently high rates of overdose death with more modest increases over time, their overdose death rate is less than half White males, who continue to exhibit the highest rates of overdose deaths.

Our study did not ascertain what may be driving these trends. However, since these increases largely reflect the rise of fentanyl, it is possible that fluctuations reflect local variations in drug supply or consumer adjustments to the potential presence of fentanyl. Ultimately, much more research is needed to understand what is driving these demographic trends, as well as how to best reach these groups with interventions and address their unique needs.

Public health policy implications

Our study of overdose deaths and drug toxicology in Delaware between 2013 and 2019 has important implications not only for Delaware, but also for the larger Mid-Atlantic region and, perhaps, the nation itself. The evolution of the opioid problem, including the rise of combined amphetamine toxicology, in overdose deaths suggests our current anti-drug policies require more attention. Overdose risk is heightened by opioid-stimulant combinations, and this risk needs to be known by clinicians and others working to address and treat substance use disorders and overdoses (LaRue et al., 2019; Jones et al., 2020). As such, opioid-specific interventions will likely have modest impacts on combined opioid-stimulant overdoses and stimulant use trends we find in Delaware and that others report elsewhere. Addressing the opioid problem is a complex task that requires strategies for immediate harm reduction, provision of treatment to people suffering from substance use disorders, and improving social opportunities and living conditions for at-risk populations. Yet, the changing demographics of overdose decedents suggests potentially unique pathways to overdose death, which require interventions tailored to meet the specific needs of target populations.

For the purposes of immediate harm reduction, consideration of novel techniques for mitigating overdose fatalities in addition to naloxone, such as supervised injection facilities or "overdose prevention sites," is warranted (Behrends et al., 2019; Potier et al., 2014). In addition to reducing the number of fatalities and reducing costs to the healthcare system (Behrends et al., 2019), supervised injection facilities can function to increase contact with medical systems and reduce the risks of adulterated drugs

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encountered by transitioning users to medications for OUD (Kral & Davidson, 2017). Also, increasing access to fentanyl testing strips can help mitigate the risks of overdose associated with using fentanyl-adulterated substances obtained on the streets (Krieger et al., 2018; Peiper et al., 2019; Reed et al., 2022). Such test strips could be made available through pharmacies, community health facilities, and distribution networks that are already focused on harm reduction efforts by providing syringe-exchange services.

Expanding access to treatment for substance abuse disorders should also be a major priority for policymakers. Given the increasing distribution of overdose deaths across diverse racial/ethnic groups, treatment expansion should focus on addressing disparities in availability, access, and retention rather than adopting a "one-size fits all" approach. For instance, nonwhite patients are generally less likely to receive a referral to substance abuse treatment, complete treatment, or receive medications for OUD compared to their White counterparts (Entress, 2021). Specifically, Black patients are less likely to complete treatment successfully compared to Whites (Sahker et al., 2015). Blacks also experience unique barriers to substance use treatment, including greater reliance on Medicaid and less geographic access to treatment facilities accepting Medicaid (Cummings et al., 2014). Latinos also generally underutilize substance abuse treatment services and are less likely than Whites to ever receive substance abuse treatment (Pinedo et al., 2018).

Moreover, these disparities in substance abuse treatment are also gendered. Black, White, and Latina women all have been found to receive/utilize treatment services more frequently than men and have greater access to services related to transportation and childcare (Guerrero et al., 2014). Additionally, in the same study, Black and Latina women display greater treatment success than their male counterparts—a difference that is especially pronounced for Latinas (Guerrero et al., 2014). Given treatment disparities and the changing demographic patterns of overdose death, policymakers should work to expand the availability of treatment facilities in underserved areas and work to remove barriers to obtaining medications for OUD. Furthermore, health-care providers and treatment facilities should aim to develop greater cultural competence in order to improve treatment retention and success among Black and Latino patients.

Finally, addressing the overdose and substance abuse problem will require long-term commitments to improving neighborhood living conditions and social opportunities for at-risk populations, as well as mitigating the harms black market activities have on local communities. Various economic phenomena such as deindustrialization, unemployment, and poverty, in general, have been associated with overdose deaths and other

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indicators of drug abuse, particularly among Whites and males (for review, see Cerdá et al., 2021). Yet, evidence suggests that the proliferation of illegal opioids has shifted the concentration of overdose deaths to neighborhoods with higher levels of concentrated disadvantage and lower White populations (Wagner et al., 2021).

While supply-side efforts aimed at controlling black market drugs are one strategy for improving communities, policymakers should be wary of overemphasizing "tough-on-crime" approaches to illegal drug control, especially as the overdose epidemic is expanding into disadvantaged neighborhoods. Some evidence indicates that policymakers are already moving in this direction, as drug-induced homicide laws intended to punish "dealers" are being increasingly adopted across the country with potentially counterproductive effects on overdoses (Carroll et al., 2021). Moreover, sentencing guidelines for fentanyl may recreate sentencing disparities of the crack-era, as distinct from other drugs, a majority of offenders apprehended for fentanyl or fentanyl analogue trafficking in 2019 were Black or low-level dealers (U.S. Sentencing Commission, 2021). Ultimately, doubling-down on criminalization may exacerbate existing social disparities and take away from efforts to address the social and economic conditions that contribute to addiction. Policymakers should begin to consider ways to address the social conditions that lead people to develop problematic substance use behaviors (Dasgupta et al., 2018).As mentioned above, US history with prior opioid and stimulant problems (e.g., cocaine, crack, methamphetamines) may threaten a repeat of race and gender disparities in interventions now that new drugs and groups other than the suburban White population, who have been the "face" of today's opioid problem, are involved. Prevention and treatment initiatives should widen to include polydrug use featuring stimulants, such as cocaine, and should be available to all groups equally to avoid the inequalities in drug control policies from the past (Deutsch-Link et al., 2021; Furr-Holden et al., 2021; Jones et al., 2020; Kunins, 2020). For example, the escalation of cocaine in Delaware's overdose deaths, and its presence in the region's drug supply, may also trigger upticks in public health risks from past cocaine and crack crises, including HIV infection, Hepatitis C, cardiac morbidity, psychopathology, heightened risk of relapse, and treatment failure. These health risks will require additional public health investment, especially for racial and ethnic minorities since their risk for combined opioid-cocaine overdose death has grown significantly and they already experience disparities in accessing and obtaining health care and drug treatment. Such investments should also address the social determinants of health that drive drug problems and should be fitted to the unique drug-related health challenges faced by women and men across race and ethnic groups.

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Disclosure statement

The authors report no conflicts of interest.

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