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Years of Life Lost to Unintentional Drug Overdose Rapidly Rising in the Adolescent Population, 2016–2020

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ABSTRACT

Purpose: Years of life lost (YLL) is an epidemiological estimate of premature death which provides increased weight to mortality at younger ages. This study aims to quantify the impact of overdose mortality in adolescents from 2016 to 2020 using YLL and document the role of illicitly manufactured fentanyl in rising overdose rates.

Methods: Data were obtained from the Centers for Disease Control and Prevention's Wide-Ranging Online Data for Epidemiologic Research mortality file for years 2016–2020 to investigate unintentional overdose in adolescents aged 10–19. Unintentional overdose rates were investigated by year, gender, age, and substances involved. YLL was calculated using the Social Security Period of Life Table by age and year. YLL to unintentional overdoses was then compared to other leading causes of adolescent death.

Results: The number of adolescent YLL to unintentional drug overdose in the United States more than doubled from 2019 to 2020 after remaining relatively stable between 2016 and 2019. In 2020, YLL to unintentional overdose accumulated to 84,179 YLL, surpassing that of cancer. Synthetic opioids including primarily illicitly manufactured fentanyl contributed to 81% of overdose deaths and 68,356 YLL, compared to 67% (26,628 YLL) in 2019. YLL to unintentional overdose during 2020 was higher for males (59,274) compared to females (24,905).

Discussion: Mortality due to unintentional overdose in adolescents reached an all-time high in 2020. The majority of deaths (81%) involved fentanyl and other synthetic opioids. The trends depicted in this study signify the need for increased harm reduction approaches and treatment of opioid use disorder in adolescents.

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IMPLICATIONS AND CONTRIBUTION

Findings from this study illustrate a concerning increase in adolescent mortality due to unintentional overdose and synthetic opioids. The trends depicted provide insight into which public health programs can allocate funding for prevention and treatment efforts to change the trajectory of YLL to unintentional overdose in adolescents.

Conflicts of interest: None of the authors involved in this work have any proprietary interests or conflicts of interest related to this submission.

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Unintentional drug overdose is a significant public health burden in the United States [1]. The number of adolescent lives lost to unintentional drug overdose in the United States more than doubled from 2019 to 2020 [2]. Although fatalities from unintentional overdose are a detriment to all members of society, mortality rates are rising more quickly in adolescents aged 10–19

than in any other age groups [2]. Although several annual national surveys such as Monitoring the Future and The National Survey on Drug Use and Health showed a decrease in adolescent-reported illicit substance use other than marijuana in 2020, deaths from unintentional overdoses continue to rise [3,4]. Adolescents are at a greater risk of death from substance use due to increased risk-taking behaviors, lack of experience, lower tolerance levels, and an *optimistic bias* that they are invincible to overdose [5]. The COVID-19 pandemic has compounded adolescents' risk of unintentional overdose with the harmful effects it has had on adolescents' mental health, home environments, financial stability, and patterns of substance use [6]. Additionally, law enforcement and epidemiological data have reported a rapid recent increase in illicitly manufactured fentanyl (IMF), making substance use particularly dangerous for adolescents [5]. Fentanyl is a powerful synthetic opioid that can be more than one hundred times the strength of morphine, posing a higher risk of both addiction and mortality by opioid poisoning [7]. Although fentanyl can be a prescription medication, the majority of overdoses and fatalities are due to IMF [7].

Unintentional drug overdose among adolescents deprives communities of their youngest members, family and friends of cherished loved ones, and adolescents themselves of experiencing the world as contributors to society. Prior work has represented this loss in years of life lost (YLL) [8–11]. YLL is an epidemiological estimate of premature death which provides increased weight to mortality at younger ages [12]. Because fewer adolescents than older adults die of unintentional overdose each year, the magnitude of overdose mortality is obscured by more commonly reported incident death rates. Examining YLL illustrates the cumulative loss to society resulting from adolescent overdose. It is essential to examine YLL to unintentional overdose in the context of other leading causes of death, as doing so may guide the allocation of government funding and intervention efforts toward areas of greatest need. This paper replicates and extends prior research by our group utilizing YLL to convey the impact of adolescent overdose on society [11]. The present study aims to quantify the impact of unintentional overdose mortality in adolescents aged 10–19 from 2016 to 2020, compare unintentional overdose mortality to other leading causes of adolescent death, and document the role of IMF and other synthetic opioids in rapidly rising overdose rates.

Methods

Data detailing summary-level death records from January 1, 2016 to December 31, 2020 were obtained from the Centers for Disease Control and Prevention's Wide-Ranging Online Data for Epidemiologic Research (CDC WONDER) mortality file [2]. A summary level is a level of geography utilized by the census bureau for data organization and tabulation. Examples of summary levels include block, school district, county, and state. The CDC WONDER database uses data from state registries based on death certificates which include underlying cause of death as reported by medical examiners and coroners, as well as demographic data such as residence (state, county when available), age group, race, ethnicity, and gender [2]. These data are based on death records received and processed by the National Center for Health Statistics. Data regarding drug-induced mortality included unintentional overdose cases, as well as cases attributed to suicide, homicide, and undetermined cause. For the portion of this study examining YLL to unintentional overdose,

YLL was calculated by multiplying the number of unintentional overdose deaths (obtained from CDC WONDER database using International Classification of Diseases, 10th Revision [ICD] codes X40–X44) and expected life spans (ELs) (obtained from the Social Security Period of Life Table) by exact age and year [13]. The Period of Life Table provides the probability of a member of a particular population living to or dying at a particular age, as well as an annual ELS by age [13]. In this table, the annual ELS is the average remaining number of years prior to death expected for a person of that age based on mortality rates for that year [13]. For example, in 2019, the ELS of a 17-year-old male was 59.93 years, compared to 59.70 years in 2017. YLL due to unintentional overdose was calculated by single age group, gender, and year and then analyzed at subgroup and aggregate levels. For example, data from ages 10 to 19 were used in sum to calculate YLL separated by male and female for each year 2016–2020. YLL was also calculated for different age groups including ages 10–13, 14–16, and 17–19 to examine trends between younger and older adolescents. In addition, YLL to unintentional overdose in adolescents aged 10–19 was calculated independently for each substance involved in the overdose by separating the data by Multiple Cause of Death (MCD) codes in the CDC WONDER database. Data regarding substances involved in unintentional overdose were obtained using MCD codes for synthetic opioids not including methadone (T40.4), heroin (T40.1), cocaine (T40.5), benzodiazepines (T42.4), other opioids (T40.2), and psychostimulants with abuse potential (predominantly methamphetamines) (T43.6). Other opioids (T40.2) is a category of prescription opioids including natural opioids such as morphine and codeine, and semi-synthetic opioids such as oxycodone, hydrocodone, hydromorphone, and oxymorphone. T40.4 included fentanyl and other synthetic opioids such as meperidine, pentazocine, propoxyphene, tapentadol, buprenorphine, and tramadol. Synthetic opioids in this category may be prescribed or manufactured illicitly. The CDC, as well as state and local health department reports have linked changes in overdose rates in this category primarily to IMF [14,15]. Using a similar approach as described above, YLL was calculated for different leading causes of death in adolescents aged 10–19 by year from 2016 to 2020. Data regarding mortality by other leading causes of death including intentional overdoses (ICD X60–X64), cancer (ICD C00–C97), heart disease (ICD I00–I09, I11, I13, I20–51), congenital disorders (ICD Q00–Q99), and chronic lower respiratory disease (ICD J40–J47) were obtained from CDC WONDER database. Analyses were conducted through use of Excel and SAS (version 9.4; SAS Institute, Cary, North Carolina). The Ohio State University Wexner Medical Center's institutional review board deemed this study exempt and granted a waiver of patient consent owing to the use of deidentified patient data. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology reporting guidelines.

Results

YLL to unintentional overdose in adolescents aged 10–19 remained relatively stable between 2016 and 2019, ranging between 37,000 and 44,000. However, 2020 demonstrated a 113% increase in YLL relative to 2019, with a total of 84,179 YLL compared to 39,579 the year prior. Males demonstrated a 121% increase in YLL from 26,817 in 2019 to 59,274 in 2020. Females demonstrated a 95% increase from 12,762 in 2019 to 24,905 in 2020 (Figure 1, Table 1). The group with the highest YLL in 2020

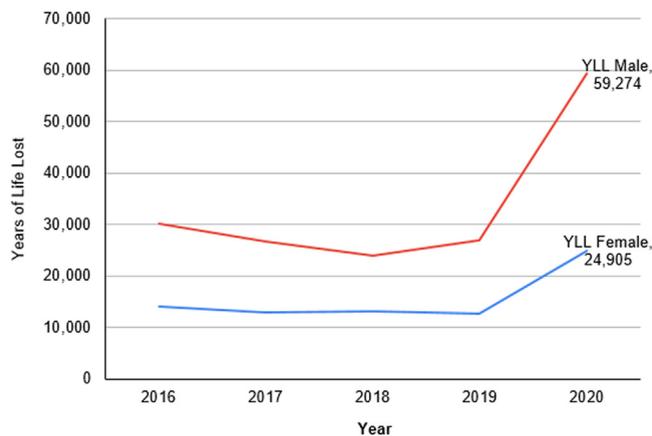


Figure 1. YLL to unintentional overdose in adolescents by gender from 2016 to 2020.

was 19-year-old males at 24,560, a 98% increase from 12,358 in 2019. The single age group with the largest percent change was 13-year-old males at 600%, with YLL increasing from 64 to 448. Older adolescents demonstrated higher rates of unintentional overdose compared to younger adolescents. For example, in 2020, there were 842 YLL among 10- to 13-year-olds, 7,879 among 14- to 16-year-olds, and 50,553 among 17- to 19-year-olds (Table 2). However, from 2019 to 2020, greater changes in YLL were seen in age groups 15 years of age and below, including a 300% increase in 11-year-old males and 14-year-old females.

IMF and other synthetic opioids other than methadone were cited in 81% of unintentional overdose deaths in this population during 2020, corresponding with 68,356 YLL. In comparison, IMF and other synthetic opioids were responsible for 26,628 YLL in 2019 and 19,868 in 2018 (Figure 2). Other substances accounted for smaller percentages of attributed unintentional overdose death in 2020. These substances include benzodiazepines (19%), methamphetamines (15%), cocaine (11%), opioids other than fentanyl or methadone (8%), and heroin (5%). The overall percentage exceeds 100 as some mortalities involved multiple substances. Changes in YLL over 2016–2020 secondary to IMF and other synthetic opioids compared to other substances are detailed in Figure 2.

From 2016 to 2019, trends in YLL to unintentional overdose, intentional overdose, cancer, heart disease, congenital disorders, and chronic lower respiratory disease remained relatively stable or showed minor variations (Figure 3). In 2019, unintentional overdose was a leading cause of adolescent mortality, trailing behind cancer, motor vehicle collisions, homicide, and suicide [2]. During this year, unintentional overdose costs adolescents more years of life (39,579) than congenital disorders (24,299), heart disease (23,600), intentional overdose (11,164), and chronic lower respiratory disease (9,072).

Leading causes of YLL between 2016 and 2020 are shown in Figure 3. Of note, YLL to unintentional overdose demonstrated a 113% increase from 2019 to 2020, while YLL to intentional overdose, cancer, heart disease, congenital disorders, and chronic lower respiratory disease remained relatively stable (<29% change). In 2020, YLL to unintentional overdose (84,179) surpassed YLL to cancer (61,277). This represented a sharp increase in unintentional

overdose fatalities from 2019, where YLL to unintentional overdose was 39,579 compared to 63,475 from cancer.

Discussion

The number of adolescent YLL to unintentional drug overdose in the United States more than doubled from 2019 to 2020 after remaining relatively stable between 2016 and 2019. The year 2020 demonstrated a 113% increase in YLL to 2019, with a total of 84,179 YLL. In 2020, YLL to unintentional overdose in adolescents aged 10–19 surpassed that of cancer and remained higher than YLL to congenital disorders, heart disease, intentional overdose, and chronic lower respiratory disease. IMF and other synthetic opioids contributed to 81% of overdose deaths and 68,356 YLL in this population during 2020, compared to 67% of deaths and 26,628 YLL in 2019. YLL to unintentional overdose during 2020 was higher for adolescent males (59,274) compared to females (24,905). As expected, the data showed that more fatalities occurred in older single age groups including ages 17, 18, and 19. However, the largest percentage change in YLL was seen in younger adolescents, which may signify an increase in mortality in upcoming years for all ages. By measuring mortality in YLL, this study quantifies the increasingly devastating impact of unintentional overdose in adolescents, especially that due to IMF and other synthetic opioids.

Existing adolescent behavioral health literature aids the interpretation of our findings. An annual survey of drug use in adolescents demonstrated that the number of 8th, 10th, and 12th graders reporting use of any illicit drug other than marijuana within the last 12 months demonstrated a decrease in 3% of respondents in 2020–2021 compared to 2019–2020 [3]. These significant declines were reported across a wide range of drugs including cocaine, hallucinogens, amphetamines, tranquilizers, and prescription opioids. These results are further supported by the annual National Survey on Drug Use and Health, which reported a decrease in past year illicit drug use in 12- to 17-year-olds during 2020 compared to years prior [4]. Although these data appear to signify a decrease in drug usage, both national surveys reported changes in methodology and collection during the pandemic. Furthermore, it is undeniable that COVID-19 has uniquely impacted adolescents in unpredictable and unaccountable ways [6]. Increased rates of adolescent mental illness and emergency department visits have been correlated to COVID-19-related stressors [16]. Research has shown that childhood trauma is related to alcohol and substance use and

Table 1

YLL to unintentional overdose in adolescents by gender from 2016 to 2020

Year	Gender	Years of life lost	Total YLL
2015	F	12,890	38,544
2015	M	25,654	
2016	F	14,039	44,233
2016	M	30,195	
2017	F	12,815	39,478
2017	M	26,663	
2018	F	13,181	37,162
2018	M	23,981	
2019	F	12,762	39,579
2019	M	26,817	
2020	F	24,905	84,179
2020	M	59,274	

F = female; M = male; YLL = years of life lost.

Table 2

YLL to unintentional overdose in adolescents by gender and single year age, 2020

	Single year ages	Death	Expected life span	YLL = expected life span × number of deaths
Female	10	2	71.23	142
	11	2	70.23	140
	12	2	69.24	138
	13	3	68.25	205
	14	12	67.26	807
	15	23	66.27	1,524
	16	33	65.29	2,155
	17	55	64.31	3,537
	18	109	63.33	6,903
	19	150	62.35	9,353
	Total	391		24,905
Male	10		66.98	0
	11	4	65.98	264
	12	2	64.99	130
	13	7	64.00	448
	14	13	63.01	819
	15	39	62.03	2,419
	16	76	61.06	4,641
	17	152	60.10	9,135
	18	285	59.15	16,858
	19	422	58.20	24,560
	Total	1,000		59,274
	Total	1,391		84,179

Note: Expected life span is the number of years prior to death expected for persons by age and gender based on annual mortality statistics. Expected life span values per the US Social Security Administration Period of Life Table [13]. YLL = years of life lost.

that adolescents with psychiatric comorbidities are at higher risk of overdose [17–19]. As a result of the COVID-19 pandemic, adolescents have been affected by stay-at-home orders, school closures, social distancing and isolation, financial insecurities, and the deaths of friends and family members [6]. These and other innumerable challenges may account for the decreased reported substance use and increased YLL and mortality rates among adolescents who use substances. In addition, COVID-19 and COVID-19-related stressors have the potential to contribute to long-term negative health outcome in adolescents including increasing overdose-related mortality rates in these groups as they mature. This is supported by prior research of the 1918 Spanish Flu pandemic, which showed that those born in 1990 had significantly higher all-cause mortality in middle and older ages than those preceding and succeeding cohorts [20].

Our data demonstrated that synthetic opioids besides methadone, and primarily IMF, were responsible for 81% of overdose deaths in this population during 2020, corresponding with 68,356 YLL. That was a marked increase from 2019 and substantially higher than other recorded substances. In 2020, IMF-related overdoses across all age groups resulted in approximately half of decedents being found without a pulse upon arrival of first responders [21]. This signifies the high potency of IMF and potential for rapid overdose. IMF is available across multiple routes of administration including injection, snorting, smoking, and taken orally as a pill. It may be mixed with or sold as other illicit drugs, such as heroin. Individuals may be unaware that their drugs are IMF-contaminated or laced drugs. Approximately 4 in 10 IMF-related overdose deaths also involved stimulants, with coingestion of substances complicating treatment and increasing overdose risk [21]. Furthermore, in contrast to other

opioid-related overdoses, IMF overdose leads to specific symptomatology such as irregular slow heart rate, dyskinesia, and rigidity that complicates management with oxygen provisions and appropriate dosing and efficacy of naloxone [22]. A US drug enforcement agency report from September 2021 stated a rapid flooding of fentanyl into counterfeit pills and that 4 out of 10 pills with fentanyl contain potentially lethal overdose [23].

Adolescent usage of IMF is of particular concern due to the increased prevalence of *optimistic bias*, a belief that the negative consequences of substance use would never happen to them [5]. Furthermore, adolescents have shorter drug use histories and lack of experience, resulting in decreased tolerance and understanding of related risks [5]. With the availability of IMF in pill form, adolescents may not fully appreciate the high risk of overdose that exists beyond injection drug use. Fentanyl may also cause young adults to become rapidly addicted. Teenagers' casual perception of drug experimentation and potential for misplaced trust in others makes them more susceptible to consume a counterfeit product or contaminated drug with unknown amounts of opioid in it, posing an increased risk of overdose [5]. In addition to the immediate risk of adverse events like overdoses and accidents, substance use in adolescents may lead to poor academic performance, job loss, teen pregnancy, sexually transmitted infection transmission, family discord, and legal consequences, as well as long-term repercussions such as poor physical and mental health, altered neurodevelopment, development of a substance use disorder, homelessness, and suicide [24–26].

In addition to gender and age, race and sociodemographics should be considered when assessing risk of unintentional overdose [11,27]. One recent report highlighted accelerating overdose mortality among Black Americans and disproportionately elevated overdose death rates among American Indian or Alaska Native individuals in 2020 [28]. Furthermore, an analysis of unintentional overdose in high school-aged adolescents demonstrated that American Indian/Alaska Native adolescents, Latinx adolescents, and adolescents in the West census region were disproportionately impacted. Corresponding overdose death rates were 2.15, 1.31, and 1.68 times the national average in 2021 [28,29]. It has also been shown that adolescents with unstable housing or a history of incarceration are at higher risk of overdose [17]. To better understand unintentional overdose in adolescents, further research should be conducted to examine differences in overdose rates by race and other sociodemographics and identify barriers to accurate tracking of overdose mortality by public health agencies.

YLL to unintentional overdose in adolescents aged 10–19 is rising at an alarming rate. From 2016 to 2020, there was a 90% increase in YLL to unintentional overdose. Even more disturbing is the 113% increase in YLL to unintentional overdose from just 2019 to 2020. Unintentional overdoses in 2020 cost US adolescents more years of life than other leading causes of death studied including cancer, congenital disorders, heart disease, intentional overdoses, and chronic lower respiratory disease. The contribution of unintentional overdoses to adolescent mortality is often overlooked due to its placement among other unintentional injuries in epidemiological reports [9]. It is important to note that for the first time in 2020, YLL to unintentional overdose outnumbered YLL to cancer. Although the YLL to cancer remained stable from 2019 to 2020, YLL to unintentional overdose sharply increased by 113%. Comparing YLL to unintentional

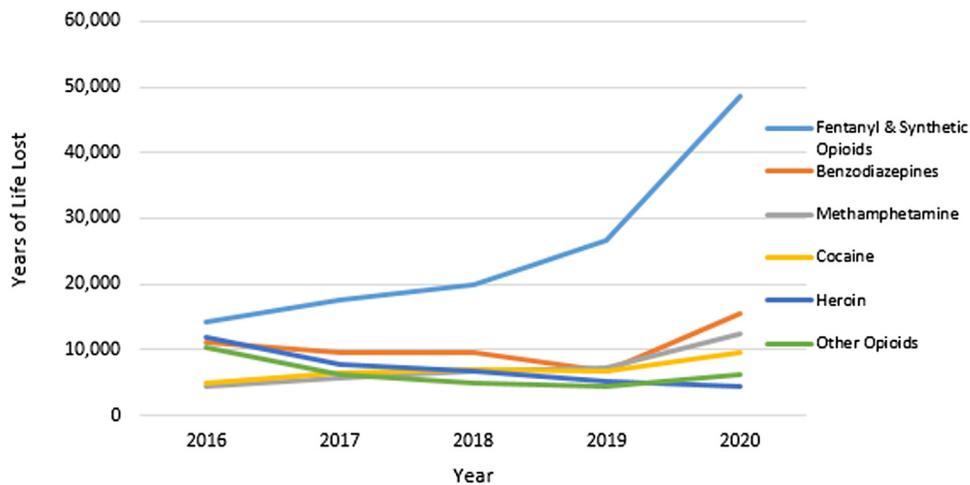


Figure 2. YLL to unintentional overdose in adolescents by substance from 2016 to 2020.

overdoses to YLL to other leading causes of death demonstrates the devastating effect substance use is having on the US adolescent population.

The 113% increase in YLL to unintentional overdose is contrasted to the change in YLL to intentional overdose, which remained stable from 2019 to 2020. However, it can often be difficult to distinguish whether an overdose is intentional or unintentional [30]. Adolescent-aged participants in a 2020 study detailed their experiences with opioid-related overdose and described the desire to reach a state of maximum high without the intention of overdosing to the point of dying [30]. Therefore, although the data collected show a significant contrast between YLL to unintentional and intentional overdoses, the difference between the two might be smaller than what is shown due to the reality that intentionality of an overdose is more of a spectrum than a binary construct [30]. Further emphasis should be placed on harm reduction techniques, education about opioids, and mental health treatment in adolescents in an attempt to lower rates of both intentional and unintentional overdose [6,30].

Harm reduction techniques are used to minimize the negative effects of health behaviors without necessarily eliminating the problematic behaviors entirely [31].

Multiple life-preserving interventions for adolescents, including medication for opioid use disorder (MOUD) and harm reduction strategies, including naloxone, have been studied and shown to be efficacious [32–34]. Use of MOUD, particularly buprenorphine, is associated with increased retention in treatment compared to adolescents receiving behavioral therapy alone [34]. Barriers to these interventions have diminished their widespread adoption, including limited addiction medicine training among pediatricians, poor familiarity with MOUD, systemic barriers to accessing MOUD, and stigma surrounding medication use [33–36]. Furthermore, racial barriers may prevent the most marginalized populations from accessing care, with one study showing that Black youth were 49% less likely to receive MOUD than White youth [33]. Expansion of these interventions as well as increased research regarding emerging treatments for MOUD can be an effective strategy to reduce

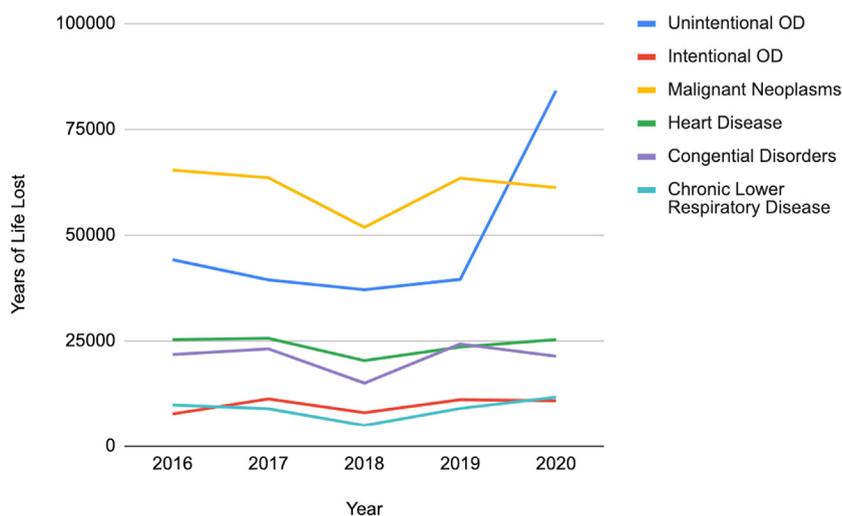


Figure 3. YLL to leading causes of death in adolescents by condition from 2016 to 2020.

adolescent YLL to IMF, with innovative approaches being studied to target adolescent populations. Virtual group counseling and virtual outpatient subspecialty substance use disorder treatment are promising innovations in care delivery for this population [37,38]. Increasing awareness of OUD and IMF in outpatient pediatric centers can facilitate referral to treatment, and use of interactive technologies can increase youth engagement and promote cost-effective treatment [39,40]. Additionally, community outreach strategies have been demonstrated to be particularly effective at connecting with marginalized youth, especially those experiencing homelessness [41]. Adolescent perception around harm reduction, including fentanyl test strips (FTS), is generally positive [42]. FTS has demonstrated high sensitivity rates, but also high false positive rates of approximately 10% [43]. Furthermore, access to FTS remains a challenge and effectiveness in adolescent populations has not yet been studied [42].

Strengths of this analysis include the use of CDC WONDER data that integrated mortality rates across all 50 US states and provided further data by age, year, and substance type. This study is limited by the accuracy of recorded mortality rates. Results of this study indicate a shocking increase in adolescent unintentional overdose rates. In actuality, counts may under-represent the true number of overdose deaths, meaning the impact of unintentional overdose may be even larger than shown in this analysis. Previous research has estimated a 34% undercount of mortality due to opioids [44]. In approximately 20% of overdose deaths, contributory substances are not specified, which may lead to under-reporting of opioid-related overdoses [45]. Coding of cause of death is dependent on the accuracy or detail of a coroner's report, and may not always designate the specific substance (e.g., "opioid" vs. "fentanyl" may get coded differently) [46]. Other issues regarding data interpretation include the grouping of mortalities from IMF with other synthetic opioids. Some groups may be more impacted by misclassification than others, as one study of classification of opioid-involved overdose deaths found that overdoses in African-American people were more likely to be classified as "unspecified narcotics" compared to overdoses in White people [47]. Although there may be limitations in differentiating some synthetic opioids apart from laboratory screenings, more precise measurement of this data and greater awareness of those affected can help us fully understand the impact of IMF and better plan harm reduction approaches. Our study portrayed the drastic increase in YLL to unintentional overdose in adolescents and the potential contribution of IMF. Although the discrepancies in current recorded IMF-related mortality rates remain unknown, the possibility of a significant underestimation should be considered. Future research can expand upon this study through investigation of the etiologies behind this increase and direct efforts toward appropriate interventions.

Compared to years prior, 2020 showed a concerning increase in adolescent mortality due to unintentional overdose and synthetic opioids. The majority of these deaths (81%) involved IMF and other synthetic opioids. For the first time in 2020, adolescent mortality due to unintentional drug overdose surpassed deaths from cancer, among other leading causes of death. Families, workplaces, and communities are increasingly deprived of the many contributions that could have been made by adolescents who lost their lives to unintentional overdose. The emerging trends depicted in this study illustrate the need for local and state interventions to address increasing premature mortality rates and substantial impacts on local communities secondary to

unintentional overdose. Primary prevention efforts including school and family-based programs as well as age-appropriate mass media and internet campaigns may be useful in reducing adolescent unintentional overdose. However, further research is needed to determine the optimal structure and content of such interventions [24].

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