

TECHNICAL NOTE**PATHOLOGY/BIOLOGY**

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Trends and Pattern of Drug Abuse Deaths in Maryland Teenagers

ABSTRACT: The Office of the Chief Medical Examiner of Maryland recorded a total of 149 drug abuse deaths of teenagers aged 13–19 years between 1991 and 2006. Of these deaths, 96 (64.4%) were caused by the use of narcotic drugs only, 29 (19.5%) by both narcotics and cocaine, four (2.7%) by both narcotics and methylenedioxyamphetamine, six (4.0%) by cocaine only, and 14 (9.4%) by volatile substances (e.g., butane, Freon, nitrous oxide, and propane). The annual death rate from drug abuse for teenagers increased from 1.4 deaths per 100,000 population in 1991 to 2.7 deaths per 100,000 population in 2006 (chi-square test for time trend, $p < 0.01$). The increase in teenager drug abuse deaths occurred in 1999 and since has remained at a higher rate. Further analysis revealed that the increase in drug abuse deaths was attributable to a large degree to narcotic drugs, particularly heroin/morphine and methadone, and was confined to teenagers residing in the suburban and rural areas.

KEYWORDS: forensic science, forensic pathology, autopsy, drug abuse death, teenagers, epidemiology, toxicology

The United States has developed a drug-oriented society. Americans, constituting only 4% of the world's population, consume 80% of the global supply of opioids, 99% of the global supply of hydrocodone, and two-thirds of the world's illegal drugs (1–4). In 2006, an estimated 20.4 million Americans aged 12 years or older were current illicit drug users. This estimate represents 8.3% of the population aged 12 years or older (5). The number of American illegal drug users has risen sharply from 12 million in 1995 to 20 million in 2006. The number of deaths caused by unintentional drug poisoning has also increased significantly (68% increase during 1999–2004) (6); the majority of this increase has been attributed to deaths associated with opioid analgesics (7). There is growing concern about an increase in illicit drug use and associated fatalities among young people, especially teenagers in the United States. The number of teen illegal drug users has more than doubled from 1.1 million in 1992 to 2.6 million in 2005 (1,2,8). The Office of the Chief Medical Examiner (OCME) has witnessed a significant increase in drug abuse deaths among teenagers in Maryland since 1999. The literature concerning drug abuse deaths in teenagers is scarce. The limited number of publications is primarily represented by case reports (9–11). Our objective was to document the epidemiologic patterns of drug abuse deaths in teenagers in the State of Maryland from 1991 to 2006.

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Materials and Methods

The OCME in Baltimore is responsible for conducting death investigations and certifying the cause and manner of unnatural and unexplained deaths, including homicides, suicides, unintentional injuries, drug-related deaths, deaths in custody, and other deaths that are sudden or unexpected in the State of Maryland. The autopsy procedures/protocols at the OCME have been consistent for the past 20 years. All deaths investigated by the OCME, which require autopsy examination, are subject to comprehensive toxicology testing for drugs and alcohol. Specimens including heart blood, femoral or subclavian blood, urine, bile, vitreous humor, stomach contents, kidney, and liver were collected from each victim at autopsy unless the condition of the victim's body precluded collection. In individuals who have died after several hours or days of hospitalization, not only was the blood collected at autopsy, but the medical facility in which the individual had been treated was contacted to provide admission blood for toxicological analysis.

The biological samples were screened for more than 100 drugs, including cocaine and its metabolites, phencyclidine (PCP), narcotics (heroin, morphine, meperidine, tramadol, methadone, codeine, hydrocodone, oxycodone, propoxyphene, and fentanyl), amphetamine, methamphetamine, MDMA, antidepressants, antihistamines, benzodiazepines, neuroleptics, sympathomimetic amines, acid/neutral drugs, acetaminophen, salicylate, common cardiac drugs, atropine, lidocaine, benzotropine, zolpidem, cyclobenzaprine, carisoprodol/meprobamate, and volatile substances. The screen tests were performed by gas chromatography and radioimmunoassay techniques. All detected drugs and/or metabolites were confirmed using gas chromatography/mass spectrometry (GC/MS). The toxicological analysis procedures were consistent during 1991–2006.

The definition of drug abuse is “the use of illegal drugs or the inappropriate use of legal drugs and the repeated use of drugs to produce pleasure, to alleviate stress, or to alter or avoid reality (or

all three)" (12). A drug-caused death is a death that can be directly attributable to or is caused by either illicit or nonillicit drug intoxication. The illicit drugs are both illegal drugs and controlled substances that are used illegally. For the purpose of this study, a drug abuse death is a death that is caused by illicit drug intoxication. A drug-related death is any death where the presence of illicit drugs is identified in the body, but is not the cause of the death. The determination of illicit drug intoxication as a cause of death was made based upon the drug concentration together with clinical history, autopsy findings, and scene investigation report.

This study was a retrospective review of autopsy cases of all teenager drug abuse deaths, aged between 13 and 19 years, investigated by the OCME in Maryland over a 16-year period from January 1991 to December 2006. The cases were analyzed as to (i) general characteristics of the victim (age, sex, and race); (ii) personal information from an interview with victim's relatives, acquaintances, or witnesses at the scene of death (including the information of any medical or drug history); (iii) information from evaluation of the scene and circumstances (including a search for the presence of drugs and drug paraphernalia); (iv) autopsy findings including the types of drugs detected by toxicology test; and (v) cause and manner of death.

The time trends in drug abuse mortality were assessed based on both the annual counts of deaths and the annual death rates. The annual death rates per 100,000 population were calculated for adolescents aged 13–19 years and for adults aged 20 years and older. These rates were based on population data from the U.S. Census. The death rates for adults were used for reference purposes. The time trends in annual death rates from drug abuse were assessed using chi-square tests and Poisson regression models. The statistical analysis was performed with the STATA software (Stata Corporation, College Station, TX).

Results

From 1991 to 2006, a total of 149 teenager deaths were determined to be the result of drugs of abuse in the State of Maryland. Annual counts of drug abuse deaths among teenagers in Maryland, along with the annual death rates per 100,000 population, are shown in Fig. 1. The number of teenager drug abuse deaths investigated by the OCME increased significantly in Maryland from six cases in 1991 to 15 cases in 2006, a 150% increase. Similarly, the annual death rate from drug abuse per 100,000 population for teenagers increased from 1.4 in 1991 to 2.7 in 2006 (chi-square test for time trend = 8.62, $p < 0.01$). There existed a marked rise starting

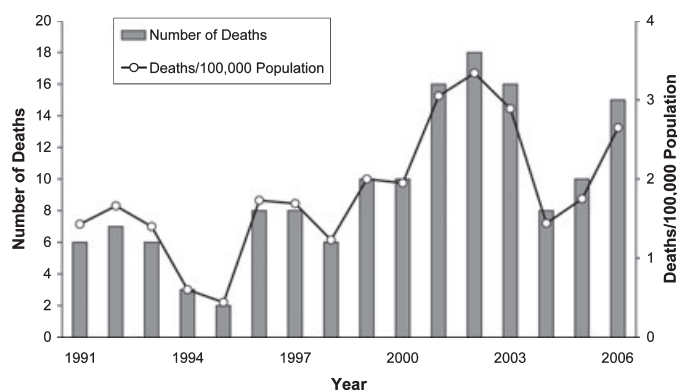


FIG. 1—Annual number and rate per 100,000 population of drug abuse deaths in teenagers, Maryland 1991–2006.

in 1999. From 1991 to 1998, the number of teenager drug abuse deaths was 46 cases (average six cases/year) while the number of teenager drug abuse deaths was 103 (average 13 cases/year) from 1999 to 2006, a 124% increase. The death rate from drug abuse in teenagers increased significantly from 1.28 per 100,000 population during 1991–1999 to 2.38 per 100,000 population during 1999–2006 ($p < 0.001$). Poisson regression modeling revealed that the risk of drug abuse death for teenagers during 1999–2006 increased 85% (adjusted risk ratio 1.85, 95% confidence interval 1.31–2.62) when compared to the preceding 8 years (1991–1998). Death rates from drug abuse in the Maryland adults during the same study period also increased significantly from 9.8 deaths per 100,000 during 1991–1998 to 14.2 during 1999–2006 ($p < 0.0001$) (see Fig. 2). There was a spike of teenager drug abuse deaths during 2001–2003. A similar spike was recorded in adult drug abuse deaths during 2002–2004.

Our study showed that narcotic drugs, especially heroin/morphine and methadone, played a major role in the rising number of teenager drug abuse deaths over the 16-year study period. From 1991 to 1998, 22 (47.8%) teenagers died of narcotic drug intoxication. Of the 22 narcotic drug abuse deaths, 18 deaths were caused by heroin/morphine use, one death was from methadone and heroin/morphine use, two deaths involved fentanyl use, and one death was caused by tramadol use. From 1999 to 2006, 74 (71.8%) teenagers died of narcotic drug use, with 41 deaths caused by heroin/morphine use, followed by methadone use ($N = 18$), oxycodone use ($N = 9$), fentanyl use ($N = 3$), methadone and heroin/morphine use ($N = 2$), and propoxyphene use ($N = 1$). The number of deaths caused by heroin/morphine and/or methadone increased 321% when comparing the years during 1991–1998 and 1999–2006. Deaths caused by combined narcotic and cocaine use also increased significantly from 11 cases during 1991–1998 to 18 cases (164% increases during 1999–2006). Of the 149 cases, 36 (24%) involved use of more than one drug including 29 cases of combined narcotic and cocaine use, four narcotic and MDMA use, and three methadone and heroin/morphine use. The number of deaths caused by volatile substances (e.g., butane, Freon, nitrous oxide, and propane) among teenagers had declined over the 16-year period from 10 cases between 1991 and 1998 to only four cases between 1999 and 2006.

Analysis of drug distribution in teenager victims during 1991–2006 revealed that narcotic drugs ($N = 94$) were implicated in 64% of deaths; narcotic and cocaine ($N = 29$) in 20%; volatile substances ($N = 14$) in 9%; cocaine ($N = 6$) in 4%; narcotic and MDMA ($N = 4$) in 3%. Over the same period, of the 7321 adult

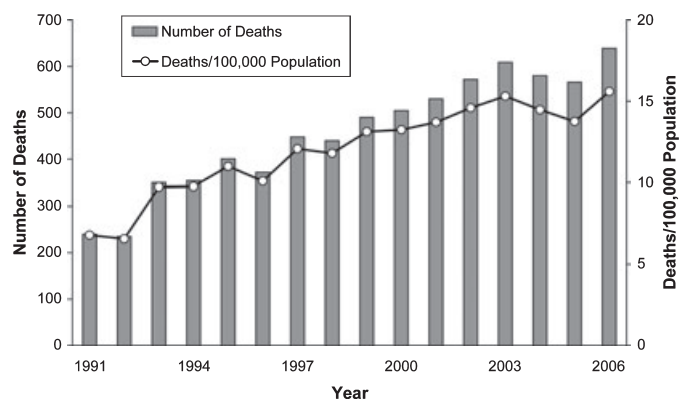


FIG. 2—Annual number and rate per 100,000 population of drug abuse deaths in adults, Maryland 1991–2006.

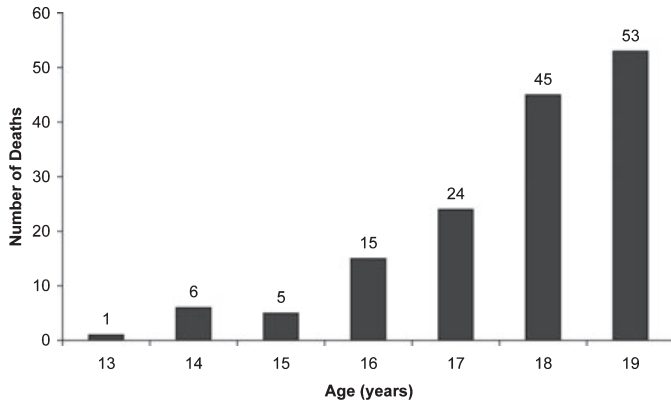


FIG. 3—Distribution of drug abuse deaths by age, Maryland 1991–2006.

drug abuse victims, 5961 (81.4%) involved the use of narcotic drugs, 1313 (17.9%) involved the use of both narcotic and cocaine, 650 (8.9%) involved cocaine, and 391 (5.4%) involved other illicit drugs. Of 5961 adult narcotic drug deaths, 4485 (75.2%) were caused by heroin/morphine.

Maryland is made up of 23 counties and Baltimore City. The majority (77.9%) of teenager drug abuse deaths occurred among county residents. Teenager drug deaths in the counties increased from 30 cases between 1991 and 1998 to 86 cases between 1999 and 2006, a 187% increase. The population of Maryland county residents in Maryland increased 20% during the 16-year period (2006 U.S. Census). The number of teenager drug abuse deaths in Baltimore City stayed relatively constant over the 16-year period with a slight decrease (17 cases between 1991 and 1998; 16 cases between 1999 and 2006).

Age distribution of drug abuse deaths in teenagers is shown in Fig. 3. The youngest victim was a 13-year-old boy who died of chlorodifluoromethane intoxication. The number of teenager drug abuse deaths increased with increasing age.

White teenagers (86%) were much more frequently involved in drug abuse deaths than black teenagers (white:black = 6.7:1). More male teenagers (81%) died of drug abuse than female teenagers (male:female = 4:1).

The distribution of drug abuse deaths by month in teenagers showed no significant difference in Maryland, with a somewhat lower frequency in April, June, and December.

The autopsy findings on teenager drug abuse victims are shown in Table 1. Of the 149 deaths, 13% exhibited fresh needle puncture marks and only 11% had needle tracks. Internal autopsy findings were relatively nonspecific and included marked pulmonary congestion and edema 149/149 (100%) with an average combined lung weight of 1226 g. Eight percent (12/149) of the cases showed

TABLE 1—Postmortem findings of teenager drug abuse deaths in Maryland (1991–2006).

Postmortem Findings	Drug Abuse Deaths (%)
External	
Fresh puncture marks	19 (12.8)
Needle tracks	16 (10.7)
Skin popping	0 (0.0)
Internal	
Early pneumonia	10 (6.7)
Focal myocarditis	2 (1.3)
HIV antibody +	2 (1.3)
Hepatitis B antibody +	4 (2.7)

TABLE 2—Scene investigation findings of teenager drug abuse deaths in Maryland (1991–2006).

Scene Investigation	No. of Deaths	% of Deaths
History		
Drug abuse by the victim	109	73.2
Drug abuse by family member	19	12.8
Depression/bipolar disorder	46	30.9
ADHD	11	7.3
Death scene locations		
Victim's residence	134	89.9
Friend's house	13	8.7
In the car	1	0.7
In the street	1	0.7
Drug paraphernalia found at scene	54	36.2
Total cases	149	

ADHD, attention-deficit hyperactivity disorder.

complications of drug abuse, including pneumonia or myocarditis. In addition, 4% of the cases were positive for HIV or hepatitis B antibodies.

Table 2 displays the scene investigation findings in teenager drug abuse deaths. Most (89.9%) of the victims were found at their own residence by family members, and c. 8.9% deaths occurred in their friend's house. In the 54 cases (36.2%), drug paraphernalia (needles, syringes, or drug substances, etc.) were found on or nearby the victims at the scene. One hundred and nine of the 149 (73.2%) drug death victims had a known history of drug abuse, 19 (12.8%) with a family history of drug abuse, and 57 (38.3) with a history of depression or bipolar disorder or attention-deficit hyperactivity disorder.

Discussion

Drug abuse encompasses all ages and socioeconomic and ethnic groups, causing significant morbidity and mortality in the United States. The pattern of drug abuse among teenagers has undergone significant change during the past 20 years. Beginning in the early 1990s, drug abuse became widespread among American teenagers and preteens (13). Statistics showed a steady increase from 1991 through 1997 in the use of drugs among students in 8th through 12th grades (13,14). Annual use of any illicit drug by high school seniors climbed steadily from a low of 27.1% in 1992 to 42.4% in 1997 (15). The rate of illicit drug use among youths aged 12 to 17 years did not change significantly from 1997 to 2002. It has been reported that the rate of illicit drug use declined among the nation's adolescents from 11.6% in 2002 to 9.8% in 2006. At the same time, the nonmedical use of prescription drugs among young adults increased from 5.4% in 2002 to 6.4% in 2006, due largely to an increase in the nonmedical use of pain relievers (5,16).

There has been no detailed analysis regarding drug abuse deaths among adolescents in the United States, although drug and alcohol abuse among teenagers continues to be one of the foremost health and social problems and is responsible for a significant percentage of the preventable premature deaths each year worldwide (9,17–19). Experimentation with drugs during adolescence is common. Unfortunately, teenagers often do not see the link between their actions today and the consequences tomorrow. This study showed a disturbingly large increase in the number of drug abuse deaths among teenagers since 1999 in Maryland. The characteristics of these cases confirmed that narcotic drugs, especially heroin/morphine, played a major role in the rising number of teenager drug

abuse deaths over the 16-year study period. Our study showed a similar increased trend in narcotic deaths, mainly heroin/morphine in the Maryland adult population over the same period.

Careful consideration of this significant increase in teenager drug abuse deaths, particularly those caused by heroin/morphine, led us to search several available sources, such as The Center for Substance Abuse Research (CESAR), the National Institute on Drug Abuse (NIDA), Office of National Drug Control Policy (ONDCP), Drug Enforcement Administration (DEA), and National Institute of Justice (NIJ), for explanation. Further study leads to identification of the following reasons:

- Heroin is abused throughout Maryland, but is centered in and around the city of Baltimore, where high-purity heroin is readily available. Baltimore is home to higher numbers of heroin addicts and heroin-related crime than almost any other city in the nation (20). These problems tend to spill over into adjoining counties where many heroin distributors maintain residences. The Office of National Drug Control Policy in Maryland reported in 2006 that the enormous demand for heroin in the Baltimore metropolitan area led to an increase in the drug's abuse among teens and young adults, who routinely drive into the city to obtain heroin for themselves and other local abusers (21). This study showed that the increased trend in drug abuse deaths was confined to teenagers residing in the suburban and rural areas. The number of teenager drug abuse deaths in Baltimore City stayed relatively constant over the 16-year period with a slight decrease. It has been reported that since 1999, Maryland younger populations were increasingly initiating heroin use, especially among suburbanites (22,23).
- Increased availability of cheap drugs, especially heroin in the Baltimore metropolitan area, led to an increase in the drug abuse among teens and young adults in Maryland. The market price of heroin continuously decreased nationwide. The Community Epidemiology Work Group of the National Institute on Drug Abuse indicates that the heroin market price reached a low in Baltimore in 2001, at \$0.39 per mg pure heroin compared with \$0.97 per mg pure heroin as the national metropolitan average (24).
- High-purity, low-cost heroin in Baltimore was associated with an increase in heroin-related deaths. Highlights from Community Epidemiology Work Group (CEWG) December 2002 Advance Report indicated that heroin abuse indicators remained high despite mixed patterns of abuse. The report stated that in Washington D.C., "heroin has surpassed crack as the drug associated with the most serious consequences: medically, legally, and in overall effects to society." In Baltimore, heroin was responsible for 50% of drug-related treatment admissions in 2000 (25). Increases in heroin-related deaths were reported in six CEWG areas, including Baltimore.
- Other possible factors include a lack of tolerance and increased use of multiple drugs in teenagers. During 1991–2006, 24% of the Maryland teenager drug victims involved use of more than one illicit drug. Deaths caused by combined narcotic and cocaine use in teenagers increased 164% during 1999–2006 when compared with the period of 1991–1998.

Methadone, a drug long valued for treating heroin addiction and for soothing chronic pain, is increasingly being abused by recreational drug users and is causing an alarming increase in overdoses and deaths in the United States (26). Methadone poisoning deaths increased 390% nationwide from 1999 through 2006. The highest rate of increase was among young persons 15–24 years of age, according to the National Center for Health Statistics (27). In

Maryland, teen methadone abuse deaths rose sharply from one death during 1991–1998 to 20 deaths during 1999–2006. The surge of methadone abuse deaths among teens serves as an alarming call for the public health agencies to enact stricter guidelines and regulations in prescribing methadone for any reason.

Because substance use typically begins during adolescence, a growing body of research has showed that there were considerable racial and ethnic differences in the epidemiology and etiology of substance use among young people (28–30). Our findings indicated that there was a substantial racial difference in teenager drug abuse deaths with white predominance (white:black = 6.7:1) while the ratio of white versus black people in Maryland was 2.3:1 (2006 U.S. Census) (31). The difference may be related to the observation that white teenagers are more likely than black teenagers to initiate and to become regular users of hard drugs (28,29); however, this may not fully explain the predominance of deaths of white teenager drug users. Further research is needed to identify the antecedents of escalation to regular use and progression of regular use across substances and to delineate the cultural and environmental factors that influence initiation of substance use and continued use among youths in different ethnic groups.

In conclusion, although in recent years there has been some decline in teen drug abuse in the United States, drug abuse deaths among teenagers continue to be a prevalent issue, which deserves attention. This study suggests that more aggressive regulatory, educational, and treatment measures are necessary to address the increase in fatal drug abuse deaths among teenagers. Prevention should be aimed at increasing public awareness of the consequences of drug abuse, improving parenting techniques, and introducing school-based drug prevention programs.

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