

SPECIAL ARTICLE

FATAL INJURIES AFTER COCAINE USE AS A LEADING CAUSE OF DEATH AMONG YOUNG ADULTS IN NEW YORK CITY

PETER M. MARZUK, M.D., KENNETH TARDIFF, M.D., M.P.H., ANDREW C. LEON, PH.D.,
CHARLES S. HIRSCH, M.D., MARINA STAJIC, PH.D., LAURA PORTERA, B.A.,
NANCY HARTWELL, B.A., AND M. IRFAN IQBAL, B.A.

Abstract Background. Cocaine intoxication can lead to fatal cardiovascular and cerebrovascular events. In addition, the neurobehavioral effects of cocaine may increase the likelihood that a user will receive violent fatal injuries. Since New York City is a center for the importation and distribution of cocaine, we sought to determine the extent of cocaine use among city residents with fatal injuries.

Methods. Among a total of 14,843 residents of New York City who received fatal injuries from 1990 through 1992, we determined the proportion who had used cocaine shortly before their deaths. We also determined the population-based rates of fatal injuries that were known to follow cocaine use and the proportion of all deaths of New York City residents that was represented by these cases for each demographic stratum. For people 15 to 44 years of age, fatal injury after cocaine use

was ranked with other causes of death as though it was a separate cause.

Results. Cocaine use, as measured by the detection of the metabolite benzoylecgonine in urine or blood, was found in 26.7 percent of all New York City residents receiving fatal injuries; free cocaine was detected in 18.3 percent. Approximately one third of deaths after cocaine use were the result of drug intoxication, but two thirds involved traumatic injuries resulting from homicides, suicides, traffic accidents, and falls. If fatal injury after cocaine use was considered as a separate cause of death, it would rank among the five leading causes of death among those 15 to 44 years of age in New York City.

Conclusions. Fatal injuries among cocaine users account for a substantial proportion of all deaths among young adults in New York City. (N Engl J Med 1995;332:1753-7.)

DEATHS involving psychoactive drugs stem not only from overdose but also from drug-induced mental states that may lead to serious injuries.¹ This case has been made most convincingly for alcohol.¹ Cocaine, however, which initially produces euphoria and hyperalertness, can also lead to agitation, paranoia, distractibility, distorted perception, and depression² — states that could increase the likelihood of violence, suicide, and accidents. Of course, finding a drug such as cocaine at autopsy does not necessarily mean that the drug directly caused an injury. Likewise, not detecting cocaine at autopsy does not exclude the possibility that cocaine was somehow involved in the chain of events leading to injury — for example, through drug dealing. Establishing the exact relation of cocaine to fatal injuries is further complicated by the pharmacokinetics of this drug. Free cocaine has an elimination half-life of 1.5 hours.^{3,4} Its metabolic product, benzoylecgonine, is not psychoactive and has a longer half-life, 7.5 hours.^{3,4} Establishing a direct relation between cocaine and fatal injuries would require assaying the serum concentrations of free cocaine in injured persons at the time of injury as well as in a demographically similar uninjured control group — a study that would be very difficult logistically, since cocaine has such a short half-life and is

illegal to possess and use. In addition, almost all previous studies in this area have relied exclusively on the detection of benzoylecgonine and have screened only a fraction of an already small sample.

We sought to determine whether evidence of cocaine use was present among residents of New York City who were fatally injured. First, we assessed the rates of detection of free cocaine itself, which reflects the use of the psychoactive drug just before a fatal injury, and then of benzoylecgonine, which indicates that cocaine was used within a few days of death. Our study could not by itself establish a cause-effect relation between cocaine use and fatal injuries, but we could determine the proportion of persons who had used cocaine immediately before injury. Second, to place these fatal injuries in better perspective in relation to all deaths, we also determined the proportion of all deaths that fatal injuries known to follow cocaine use represented among various demographic strata in New York City. Because fatal injuries and cocaine use are more common among young people, we focused this component of our study on people 15 to 44 years of age.

METHODS

Classification of Fatal Injuries

We studied all deaths among New York City residents from 1990 through 1992 that the medical examiner certified as being due to intentional or unintentional injury. The deaths were studied at the time they occurred, at the Office of the Chief Medical Examiner, which has jurisdiction for all five counties of the city. The deaths were grouped according to their causes as classified by the *International Classification of Diseases, Ninth Revision, Clinical Modification*⁵; the categories included accidents (E800 to E949), suicides (E950 to E959), homicides (E960 to E978), and deaths whose manner was undetermined (E980 to E989). Among the accidents, we identified a sub-

From the Section of Epidemiology, Department of Psychiatry (P.M.M., K.T., A.C.L., L.P., N.H., M.I.I.), and the Department of Public Health (K.T.), Cornell University Medical College, New York; and the Office of Chief Medical Examiner, City of New York, and the Department of Forensic Medicine, New York University School of Medicine, New York (C.S.H., M.S.). Address reprint requests to Dr. Marzuk at the Department of Psychiatry, Box 147, New York Hospital-Cornell Medical Center, 525 E. 68th St., New York, NY 10021.

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group of cocaine overdoses to determine the proportion of all fatal injuries involving cocaine that were directly due to acute drug intoxication. Each file from the medical examiner was reviewed for demographic information; the time, date, and location of injury and death; the manner and cause of death; and toxicologic findings.

Toxicologic Procedures

Urine and blood specimens collected at autopsy were stored at 4°C until they were assayed. Blood specimens were collected in tubes containing sodium fluoride. A single toxicologic laboratory at the Office of the Chief Medical Examiner analyzed all specimens. Benzoyllecgonine was initially screened for in urine, with the use of an enzyme immunoassay. A specimen was considered positive if the concentration of benzoyllecgonine was at least 0.3 mg per liter. If urine was not readily available at autopsy, benzoyllecgonine was screened for in blood, by radioimmunoassay. A blood specimen was considered positive if the concentration of benzoyllecgonine was at least 0.1 mg per liter. Positive immunoassay findings were substantiated in another tissue by radioimmunoassay.

Blood was screened for cocaine by gas chromatography, with the use of a nitrogen-phosphorus detector. A specimen was considered positive if the concentration of cocaine was 0.1 mg per liter or higher. All positive findings were confirmed by gas chromatography and mass spectrometry.

Because ethanol is often used with or immediately after cocaine, we also assessed the proportion of people with fatal injuries in whom ethanol was detected. Blood was analyzed for ethanol by head-space gas chromatography.

Detection of Cocaine Use

We assessed cocaine use among people with fatal injuries in two ways: first, through assay for free cocaine, and second, through assay for benzoyllecgonine. Because free cocaine has a short half-life, the number of deaths in which cocaine assays were positive represents a very conservative estimate of proximal cocaine use among people with fatal injuries but may closely reflect the proportion whose behavior might have been affected by the drug at the time of injury. Counting the cases in which assays were positive for benzoyllecgonine, which has a longer half-life, yields a more accurate estimate of the total number of fatal injuries among cocaine users. By design, our estimates can represent only a conservative undercount of all persons who might have used the drug before death, for two reasons. First, because of family objections to autopsy, not everyone who dies of injuries is screened for cocaine and benzoyllecgonine. Second, because benzoyllecgonine is detectable in urine or blood for up to 48 hours after cocaine use³ but not much longer if typical amounts are used, it is not possible to infer drug use before injury for people who survive their injuries for several days before dying. In practice, however, most people who died of injuries had not received prolonged medical care and died instantly (e.g., of firearm-associated injuries, falls from heights, or hanging) or in a matter of hours (e.g., of poisoning).

We determined the proportion of all people who died of fatal injuries in whom free cocaine was detected and the proportion in whom benzoyllecgonine was detected. Because of the different demographic characteristics associated with the various causes of death, these proportions were then adjusted for age, sex, and race or ethnic group, with the New York City population, as recorded by the 1990 U.S. Census,⁶ used as the standard.

Proportionate Mortality and Rank-Order Causes of Death

We obtained a count of all deaths from any cause among residents of New York City from 1990 through 1992 — stratified according to age, sex, and race or ethnic group — from the New York State Department of Health. The proportionate mortality, both of fatal injuries and of benzoyllecgonine-positive fatal injuries, was then calculated as the number of fatal injuries or benzoyllecgonine-positive fatal injuries for each demographic stratum divided by the total mortality from all causes for that stratum. Because cocaine use and fatal injuries are principally confined to younger people, we present summary data for people of all ages but focus on those 15 to 44 years of age.

We also ranked fatal injuries involving cocaine users in relation to the leading causes of death in each demographic stratum of young

adults. Mortality rates specific for age and race or ethnic group for the five leading causes of death were also calculated separately for white, black, and Hispanic men and women 15 to 24 and 25 to 44 years of age, on the basis of 1990 U.S. Census data⁶ for New York City. Rates were not calculated for "other" racial or ethnic groups, a category composed of subgroups with very low individual base rates of mortality. Standardized mortality ratios were then calculated for each of the five leading causes of death in the demographic groups, with the rates for white men and white women used as the reference death rates. To calculate the standardized mortality ratios, the total number of observed deaths from a given cause in a specific demographic group was divided by the number of deaths expected on the basis of the population of the demographic group and the reference death rate.⁷

RESULTS

Cocaine Use among People with Fatal Injuries

There were a total of 14,843 residents of New York City with fatal injuries during the three-year study period (Table 1). Of all the people with fatal injuries, 12,960 (87.3 percent) were tested for benzoyllecgonine at autopsy, 12,745 (85.9 percent) were tested for cocaine, and 12,976 (87.4 percent) were tested for ethanol. In the age group of particular interest in this study (15 to 44 years of age), 96.2 percent of all the people with fatal injuries were tested for benzoyllecgonine, 95.0 percent were tested for cocaine, and 96.2 percent were tested for ethanol. The rates of testing for benzoyllecgonine according to race or ethnic group were 91.8 percent for non-Hispanic whites; 97.1 percent for non-Hispanic blacks; 97.8 percent for Hispanics; and 91.4 percent for all other groups.

There were 3961 cases in which benzoyllecgonine was detected (crude proportion of all fatal injuries, 0.267; adjusted for age, sex, and race, 0.207) and 2713 cases in which free cocaine was detected (crude proportion of all fatal injuries, 0.183; adjusted proportion, 0.144). With regard to the manner of death, cocaine use was detected in 69.7 percent of all accidental poisonings, 29.2 percent of homicides, 15.3 percent of suicides, and 9.3 percent of traumatic accidents (Table 1). Ethanol was detected in 28.1 percent of all cases of fatal injury.

Among people 15 to 44 years of age ($n=9702$), benzoyllecgonine was detected in 35.8 percent of fatal-injury cases, ethanol in 33.7 percent, and free cocaine in 24.6 percent.

Among all 3961 cases of fatal injuries after cocaine use, accidental overdoses — the most directly drug-related cause of death — accounted for 1384 cases, or 34.9 percent. Two thirds of the cases of fatal injury in which cocaine use was detected, therefore, were caused by physical violence and not by direct toxic effects. Ethanol was detected concurrently in 40.8 percent of the cases in which tests for benzoyllecgonine were positive and 45.1 percent of those in which tests for free cocaine were positive.

Proportionate Mortality

There were 213,825 deaths among New York City residents of all ages during the study period. (For 201,622 of these, a specific racial or ethnic designation was reported.) Fatal injuries were responsible for 6.9

Table 1. Distribution of Fatal Injuries Known to Follow Cocaine Use among New York City Residents, 1990 to 1992, According to the Manner of Death.

MANNER OF DEATH	ALL FATAL INJURIES	FATAL INJURIES FOLLOWING COCAINE USE			
		BENZOYLECGONINE-POSITIVE		COCAINE-POSITIVE	
		Crude	Adjusted*	Crude	Adjusted*
	no.	percent of all fatal injuries			
Homicide	6,240	29.2	21.3	19.6	15.6
Suicide	1,895	15.3	14.7	10.5	10.0
Accident (total)	6,306	28.3	23.9	19.8	16.3
Drug overdose	1,986	69.7	61.5	50.8	43.2
Other	4,320	9.3	10.1	5.5	6.0
Undetermined	402	16.9	13.3	11.2	9.2
All fatal injuries	14,843	26.7	20.7	18.3	14.4

*Values have been adjusted for age, sex, and race or ethnic group, with the 1990 U.S. Census of the New York City population used as the standard.

percent of all deaths in all age groups. These injuries accounted for 11.5 percent of all deaths among those 14 years of age or younger and 2.7 percent of all deaths among those over the age of 44. However, injuries accounted for 71.3 percent of all deaths among people between 15 and 24 years of age and 24.3 percent of all deaths among those between 25 and 44.

The 3961 fatal injuries following cocaine use were responsible for only 1.9 percent of all deaths among all age groups. These injuries accounted for 0.4 percent of all deaths among those 14 years of age or younger and 0.3 percent of all deaths among those over the age of 44. However, fatal injuries after cocaine use accounted for 14.6 percent of the deaths of people between 15 and 24 years of age and 10.3 percent of the deaths of those between 25 and 44.

Leading Causes of Death among Young Adults in New York City

The five leading causes of death and the mortality rates associated with them for white, black, and Hispanic adults are shown in Table 2 (for people 15 to 24 years of age) and Table 3 (for those 25 to 44). If fatal injury after cocaine use were categorized as a separate cause of death, among people 15 to 24 years of age it would rank second for white, black, and Hispanic men and second for black and Hispanic women. For white women, it would rank fifth.

Among black and Hispanic men 25 to 44 years of age, fatal injuries after cocaine use ranked third behind the acquired immunodeficiency syndrome (AIDS) and other fatal injuries not known to follow cocaine use. For black women in this age group, fatal injuries after cocaine use ranked fourth after AIDS, cardiovascular disease, and cancer. For white men and women, as well as Hispanic women, such injuries ranked fifth.

The disproportionate burden of mortality due to fatal injuries after cocaine use borne by black and Hispanic youths in these age groups is demonstrated further in Table 4. The standardized mortality ratios show that death rates among black and Hispanic youths are higher than those among white youths for all five lead-

ing causes of death, the greatest difference being between rates of fatal injuries in which cocaine was detected.

DISCUSSION

We found that at least one in four residents of New York City who died of intentional or unintentional injuries was a recent cocaine user. Cocaine itself was detected at autopsy in nearly one in five fatal-injury cases.

We chose to refer to fatal-injury cases in which benzoylecgonine use was detected as fatal injuries after cocaine use. The word "after" emphasizes that cocaine use closely preceded the fatal injury but that it could not be construed as causative. Nonetheless, the findings can be examined in relation to data on cocaine use by living people in the general population. Household surveys of the New York City general population estimated that the frequency of cocaine use in the preceding 30

Table 2. Leading Causes of Death, Mortality Rates, and Proportionate Mortality for New York City Residents, 15 to 24 Years of Age, from 1990 to 1992.

CAUSE	NO. OF DEATHS	RATE*	PM†
Non-Hispanic whites			
Men			
All causes	544	103.2	100.0
Other fatal injuries	205	38.9	37.7
Fatal injuries after cocaine use	50	9.5	9.2
Cancer	29	5.5	5.3
Cardiovascular disease	22	4.2	4.0
AIDS	16	3.0	2.9
Women			
All causes	174	32.5	100.0
Other fatal injuries	50	9.3	28.7
Cancer	23	4.3	13.2
AIDS	14	2.6	8.1
Cardiovascular disease	10	1.9	5.7
Fatal injuries after cocaine use	9	1.7	5.2
Non-Hispanic blacks			
Men			
All causes	1525	355.5	100.0
Other fatal injuries	991	231.0	65.0
Fatal injuries after cocaine use	204	47.5	13.4
AIDS	49	11.4	3.2
Cardiovascular disease	40	9.3	2.6
Cancer	37	8.6	2.4
Women			
All causes	376	79.8	100.0
Other fatal injuries	120	25.5	31.9
Fatal injuries after cocaine use	44	9.3	11.7
AIDS	38	8.1	10.1
Cancer	28	5.9	7.5
Cardiovascular disease	27	5.7	7.2
Hispanics			
Men			
All causes	1092	230.7	100.0
Other fatal injuries	741	156.5	67.9
Fatal injuries after cocaine use	244	51.5	22.3
AIDS	51	10.8	4.7
Cancer	24	5.1	2.2
Cardiovascular disease	14	3.0	1.3
Women			
All causes	244	52.7	100.0
Other fatal injuries	106	22.9	43.4
Fatal injuries after cocaine use	38	8.2	15.6
AIDS	23	5.0	9.4
Cardiovascular disease	18	3.9	7.4
Cancer	15	3.2	6.2

*The rate was calculated as the number of deaths per 100,000 person-years.

†PM denotes proportionate mortality (the number of deaths with a specific cause divided by all deaths, and the result converted to a percentage).

Table 3. Leading Causes of Death, Mortality Rates, and Proportionate Mortality for New York City Residents, 25 to 44 Years of Age, from 1990 to 1992.

CAUSE	NO. OF DEATHS	RATE*	PM†
Non-Hispanic whites			
Men			
All causes	5874	367.6	100.0
AIDS	2702	169.1	46.0
Other fatal injuries	758	47.4	12.9
Cardiovascular disease	564	35.3	9.6
Cancer	449	28.1	7.6
Fatal injuries after cocaine use	380	23.8	6.5
Women			
All causes	1698	107.5	100.0
Cancer	475	30.1	28.0
AIDS	320	20.3	18.8
Cardiovascular disease	198	12.5	11.7
Other fatal injuries	194	12.3	11.4
Fatal injuries after cocaine use	79	5.0	4.7
Non-Hispanic blacks			
Men			
All causes	7383	924.7	100.0
AIDS	2861	358.3	38.8
Other fatal injuries	1118	140.0	15.1
Fatal injuries after cocaine use	1064	133.3	14.4
Cardiovascular disease	604	75.7	8.2
Cancer	314	39.3	4.3
Women			
All causes	3483	342.2	100.0
AIDS	1108	108.9	31.8
Cardiovascular disease	434	42.6	12.5
Cancer	414	40.7	11.9
Fatal injuries after cocaine use	315	31.0	9.0
Other fatal injuries	232	22.8	6.7
Hispanics			
Men			
All causes	5673	657.7	100.0
AIDS	2408	279.2	42.5
Other fatal injuries	1147	133.0	20.2
Fatal injuries after cocaine use	867	100.5	15.3
Cardiovascular disease	303	35.1	5.3
Cirrhosis	192	22.3	3.4
Women			
All causes	1683	176.0	100.0
AIDS	650	68.0	38.6
Cancer	198	20.7	11.8
Other fatal injuries	197	20.6	11.7
Cardiovascular disease	151	15.8	9.0
Fatal injuries after cocaine use	139	14.5	8.3

*The rate was calculated as the number of deaths per 100,000 person-years.

†PM denotes proportionate mortality (the number of deaths with a specific cause divided by all deaths, and the result converted to a percentage).

Table 4. Standardized Mortality Ratios for the Five Leading Causes of Death among Young Adult Residents of New York City, 1990 to 1992.

	AGE 15 TO 24 YEARS*				AGE 25 TO 44 YEARS†			
	MEN‡		WOMEN§		MEN‡		WOMEN§	
	Black	Hispanic	Black	Hispanic	Black	Hispanic	Black	Hispanic
All causes of death	3.45	2.24	2.46	1.62	2.52	1.79	3.18	1.64
Five leading causes								
Fatal injuries after cocaine use	5.01	5.42	5.50	4.83	5.60	4.22	6.19	2.91
Other fatal injuries	5.94	4.02	2.74	2.46	2.95	2.80	1.85	1.68
AIDS	3.81	3.59	3.10	1.91	2.12	1.65	5.36	3.35
Cardiovascular disease	2.22	0.71	3.02	2.05	2.14	1.00	3.41	1.26
Cancer	1.57	0.92	1.38	0.75	1.40	0.77	1.35	0.69

*The number of observed deaths is shown in Table 2.

†The number of observed deaths is shown in Table 3.

‡Age-specific death rates for white men were used as the reference values.

§Age-specific death rates for white women were used as the reference values.

days was less than 1.3 percent overall, and only 3.0 to 4.1 percent among young Hispanic and black men, the demographic groups with the highest rates of use.⁸ The rate of cocaine use a few hours or at most a few days before death by people who died of injuries, when adjusted for the New York City general population, was at least 20.7 percent. Thus, it is unlikely that our findings reflect merely the base-line rate of use by the population as a whole. In addition, more than two thirds of the people who were identified as cocaine users through the detection of benzoylecgonine also tested positive for neurobehaviorally active free cocaine, suggesting that most people who died shortly after using cocaine were under the influence of the drug at the time of injury.

The contribution of cocaine use to overall mortality in New York City is small if one considers all age groups. However, if fatal injuries among cocaine users were considered as a separate category, they would rank among the five leading causes of death among all young adults in New York City. In fact, for those 15 to 24 years of age, fatal injuries after cocaine use exceeded other causes of death, including AIDS, cancer, and heart disease, for all racial and ethnic groups except white women.

Cocaine use is reportedly declining after reaching a peak in the mid-to-late 1980s.⁸ However, use among people who die of injuries remains very high. For instance, the rates of use in cases of suicide and motor vehicle accidents in this study are essentially unchanged from rates we reported in earlier studies conducted in the mid-1980s in New York City.⁹⁻¹¹ Cocaine users who die of injuries may be heavy users of the drug, and heavy use of cocaine may have continued unabated in the population, particularly in some poor communities in which networks for the distribution of "crack" cocaine are well organized and entrenched.¹² Young black and Hispanic people have higher mortality rates than white people for all leading causes of death except cancer, and the rates are highest for fatal injuries after cocaine use.

Additional studies are needed to determine the exact role of cocaine in fatal injuries. Accidental fatal overdoses of cocaine represent the most direct link between cocaine and fatal injury. Such deaths typically stem from cardiac arrhythmias, myocardial infarction, stroke, ruptured aneurysms, or hyperthermia.^{13,14} These direct pharmacologic effects of cocaine accounted for approximately one third of all fatal-injury cases involving cocaine use. More striking, however, is the finding that cocaine use was detected consistently in all types of fatal-injury cases. Thus, the principal effect of cocaine use on mortality, not unlike that of ethanol, may lie in its association with traumatic injury,

as in cases of homicide, suicide, motor vehicle accidents, and falls.

It is possible that cocaine, like ethanol, increases the risk of injury by inducing states of drug intoxication² (e.g., agitation, aggression, and distorted perception) or drug withdrawal¹⁵ (e.g., distractibility, somnolence, and depression). In addition, cocaine users frequently use other drugs, such as ethanol or opiates, simultaneously, either to modify cocaine's psychological effects or to blunt unpleasant side effects.¹⁵ Ethanol, for instance, was detected in 45 percent of the cases in which cocaine was detected.^{8,9} Thus, cocaine may influence the risk of injury because it is used concurrently with other psychoactive drugs. However, in more than half the cases in which cocaine was detected, alcohol was not, suggesting that conjoint alcohol use cannot completely explain the role of cocaine in fatal injuries. It is also possible that cocaine use and injuries are linked through an intermediate third factor. Cocaine users may simply be more aggressive, risk-taking people, whose personality style — independently of drug use — predisposes them to fatal injuries.¹⁶ Likewise, buying and dealing illegal drugs lead to involvement in dangerous activities that are themselves associated with injury, such as prostitution and crime.

Several methodologic issues warrant comment. We investigated almost 90 percent of fatal-injury cases in all age groups for cocaine use and over 96 percent of the cases involving young adults. Nonetheless, uninvestigated cases were considered negative, and cases involving people who had used cocaine but who had long survival times after injury were also counted as negative. Thus, our estimate of the involvement of cocaine in fatal injuries is conservative. It is also likely that our total number of cases with positive tests for free cocaine represents an undercount, because cocaine undergoes some temperature-dependent hydrolysis to form benzoylecgonine in the blood after death.^{17,18}

Our results apply only to New York City. It is possible, however, that other cities with high rates of cocaine use in the general population may have similar mortality patterns. In some cities, for example, benzoylecgonine has been detected in 20 to 30 percent of homicide victims.¹⁹⁻²³

In summary, cocaine use was detected in a substantial proportion of all types of fatal injuries in New York

City. Additional studies are needed to determine whether cocaine has a causative role in such injuries.

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