Overdose deaths attributed to methadone and heroin in New York City, 1990–1998

W. K. Bryant[1,2], S. Galea[1,2], M. Tracy[1], T. Markham Piper[1], K. J. Tardiff[3] & D. Vlahov[1,2]

Center for Urban Epidemiologic Studies, New York Academy of Medicine[1], Department of Epidemiology, Columbia University Mailman School of Public Health[2] and Department of Psychiatry, Weill Medical College of Cornell University, New York, NY, USA[3]

Correspondence to:
Sandro Galea
Center for Urban Epidemiologic Studies
New York Academy of Medicine
1216 Fifth Avenue
New York, NY 10029
USA
Tel: +1 212 987 2560
Fax: +1 212 876 6220
E-mail: sgalea@nyam.org

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ABSTRACT

Aims Methadone treatment has been shown to be an effective intervention that can lower the risk of heroin-induced overdose death. Recent reports have suggested increases in methadone-induced overdose deaths in several locations in the USA and in Europe. This study investigated the role of methadone and opiates in accidental overdose deaths in New York City.

Design We analysed data from the Office of the Chief Medical Examiner to examine all accidental drug overdose deaths in New York City between 1990 and 1998.

Findings Of 7451 total overdose deaths during this period, there were 1024 methadone-induced overdose deaths, 4627 heroin-induced overdose deaths and 408 overdose deaths attributed to both methadone and heroin. Fewer than a third as many accidental overdose deaths were attributed to methadone than were attributed to heroin during this period. The proportion of accidental overdose deaths attributed to methadone did not change appreciably (12.6–15.8% of total overdose mortality), while the proportion of overdose deaths attributed to heroin increased significantly (53.5–64.2%) during the period of study.

Conclusions There was no appreciable increase in methadone-induced overdose mortality in New York City during the 1990s. Both heroin-induced overdose mortality and prescriptions of methadone increased during the same interval.

KEYWORDS Methadone, opiates, overdose.

INTRODUCTION

Accidental drug overdose is a substantial cause of morbidity and mortality among drug users (Cherubin *et al.* 1972; Helpern 1972; Joe & Simpson 1987; Oppenheimer *et al.* 1994; Bargagli *et al.* 2001; Tyndall *et al.* 2001; Hickman *et al.* 2003). Methadone treatment has been shown to be an effective treatment for opiate addiction (Gronbladh *et al.* 1990; Kleber *et al.* 1980; Bertschy 1995), reducing morbidity and mortality associated with heroin use (Stark *et al.* 1996; MacGowan *et al.* 1997), particularly accidental overdose (Caplehorn *et al.* 1994; Caplehorn *et al.* 1996).

Recent reports have suggested that increases in overdose deaths attributed to methadone (Cairns *et al.* 1996; Hall, Lynskey & Degenhardt 2000). Hickman *et al.* (2003) investigated these claims in England and Wales and found that as many overdose deaths were attributable to methadone as were attributable to heroin between 1993 and 1998. Hickman *et al.* also found that the rate of increase in overdose deaths due to heroin was higher than the rate of increase in deaths due to methadone (24.7% versus 9.4%, respectively, with the ratio of heroin to methadone moving from 1 : 1 to 2 : 1) during the period of study (Hickman *et al.* 2003).

Comparable analyses in the USA that have explored the role of methadone in drug overdose deaths during the 1990s are scarce. Most reports about methadone-induced overdose in the USA have been in the popular media. One newspaper report cited a two-fold increase in

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the number of emergency room visits connected to methadone between 1999 and 2001 in the USA (Belluck 2003; extracted from Drug Abuse Warning Network). A few states, including Florida and Maine, have reported an increase in methadone-induced overdose deaths (Florida Department of Law Enforcement 2002; Sorg & Greenwalk 2002). The only peer-reviewed study about this issue in the USA of which we are aware showed a five-fold increase in methadone-induced overdose deaths (from 12 deaths to 80) in North Carolina from 1997 to 2001. That study attributed nearly all of this increase in methadone-induced overdose deaths to the use of methadone for pain management and methadone diverted for illicit use (Ballesteros *et al.* 2003). This limited available data about the role of methadone in overdose deaths in the USA precludes drawing conclusions about whether or not methadone is a significant contributor to overdose in the USA or whether its role in overdose deaths might be increasing.

Drug overdose morbidity and mortality is a substantial problem in New York City (NYC), the largest city in the USA. NYC hospital emergency departments receive twice as many drug-induced visits as would be expected on a population basis [New York City Department of Health (NYCDOH) 2002; Galea & Coffin 2003]. Death due to accidental drug overdose has been one of the top 10 causes of death in NYC from 1993 to the present [New York City Department of Health and Mental Hygiene (NYCDOHMH) 2003]. We examined data on all accidental drug overdose deaths in NYC between 1990 and 1998 in order to: (a) assess the changing contribution of methadone to overdose death over time; (b) compare the relative contributions of methadone and heroin to overdose deaths to allow comparison with data reported by Hickman *et al.* (2003) in the UK, and (c) compare characteristics of methadone and heroin decedents.

METHODS

Study population

All cases of accidental drug overdose deaths in NYC from 1990 to 1998 were identified through standardized manual review and abstraction of medical files in the Office of the Chief Medical Examiner of New York City (OCME). The OCME is responsible for investigating all deaths of people believed to have died in an unnatural manner. Thus, all accidental overdose deaths in NYC are reviewed by the OCME and would have been included in the charts reviewed for data extraction.

Data collection

Data regarding demographics, cause of death, circumstances of death and toxicology were collected from the OCME files by trained abstractors using a standardized protocol and data collection forms. The OCME investigators used the decedent's medical history, the circumstances and environment of the death, autopsy findings and laboratory data to attribute the cause of death to each case reviewed. Therefore, classification of cause of death is made by the OCME and differs from simple presence or absence of drugs in a toxicological screen. For example, a decedent who is positive for the presence of heroin may or may not be classed as a heroin-induced overdose death, depending on the circumstances of the death and other features of the medical examiner's investigation. Similarly, it is possible that the medical examiner will consider heroin a contributing cause of death even if heroin is not present in the toxicological analysis (e.g. a decedent examined long after death, found surrounded by obvious heroin-related paraphernalia). Attributions of drugs as a cause of death by the OCME are not mutually exclusive: an overdose death may be attributed to more than one drug.

Rates of autopsy vary by manner of death. During 1990–1998, 99.8% of homicides, 88.2% of manner-undetermined deaths, 85.6% of suicides and 79.4% of accidents underwent complete autopsy. All autopsied cases undergo toxicological screening. In some cases in which an autopsy was not performed, specimens were still submitted for toxicological analysis. Previous studies provide further details on this data collection methodology and the toxicological measurement of drugs involved in these cases (Tardiff *et al.* 1994, 1996).

Statistical analyses

Analyses were conducted on all accidental drug overdose decedents aged 15–64 years. Overdose deaths in which methadone was cited as a cause of death, alone or in combination with other drugs (including heroin), were classified as methadone-induced overdose deaths; likewise for heroin-induced overdose deaths. We calculated the total number and proportion of overdose deaths attributed to methadone and to heroin in NYC for each year from 1990 to 1998. We used χ^2 tests for trend to assess the significance of changes in the number and proportion of methadone- and heroin-induced overdose deaths over time.

We described relevant characteristics of all accidental drug overdose deaths. Characteristics of interest included sex, race, age, borough of death, year of death and drugs detected, focusing on cocaine, methadone, heroin, cannabis and alcohol as the drugs that were most frequently positive in drug toxicology. Drug categories were not mutually exclusive: a decedent could have positive toxicology for several of these drugs.

We used logistic regression to assess bivariate relations between each of the decedent characteristics of

interest and the likelihood of methadone- and heroin-induced overdose death within all overdose deaths. This method stands in contrast with the analysis conducted by Hickman *et al.* (2003), which investigated only methadone- and heroin-induced overdose deaths without regard to overdose deaths attributed to other drugs. All covariates that were significantly associated ($P < 0.1$) with methadone- or heroin-induced overdose death were included in multivariate models.

RESULTS

Out of a total of 7451 accidental drug overdose deaths in NYC between 1990 and 1998, there were 5243 overdose deaths attributed to methadone or heroin (70.4%). Methadone-induced overdose deaths totaled 1024, and heroin-induced overdose deaths 4627; these figures include an overlap of 408 decedents whose deaths were attributed to both substances. There were 121 overdose deaths due to methadone alone, in the absence of any other substances, during this period (11.8% of all methadone overdose deaths), and 911 deaths due to heroin overdose alone (19.7% of all heroin overdose deaths).

Of the 7451 accidental drug overdose deaths that occurred in NYC from 1990 to 1998, 79.5% of decedents were male, 33.7% were white, 36.3% black and 30.0% Hispanic (Table 1). Over 70% of overdose decedents were between the ages of 25 and 44. Deaths were distributed throughout NYC, with 32.8% in Manhattan, 23.2% in the Bronx, 26.4% in Brooklyn and smaller proportions in Queens (15.2%) and Staten Island (2.4%). The most prevalent drugs detected in toxicological screening were cocaine (69.0%), heroin (65.5%) and alcohol (42.3%).

Figure 1 shows the number of accidental overdose deaths attributed to methadone and heroin among decedents aged 15–64 years in NYC between 1990 and 1998. The number of overdose deaths attributed to methadone remained relatively stable during this time period, with a high of 145 methadone-induced overdose deaths in 1991 and a low of 81 deaths in 1997 (χ^2 test for trend, $P = 0.156$). Overdose deaths attributed to heroin rose from 287 in 1990 to a peak of 676 in 1993. This rate plateaued around 650 deaths per year in 1994 and 1995, and then began to decline, falling to 483 heroin-induced overdose deaths in 1998 (χ^2 test for trend, $P = 0.005$).

Figure 2 shows the percentage of accidental overdose deaths attributed to methadone or heroin in NYC between 1990 and 1998. Over this time period, the proportion of overdose deaths attributed to methadone decreased significantly from 15.8% in 1990 to 12.6% in 1998, with a high of 20.1% in 1991 and a low of 10.0% in 1997 (for trend, $P < 0.001$). During that same period, the proportion of overdose deaths attributed to heroin rose significantly from 53.5% in 1990 to 64.2% in 1998, with a low of 48.9% in 1991 and a high of 68.2% in

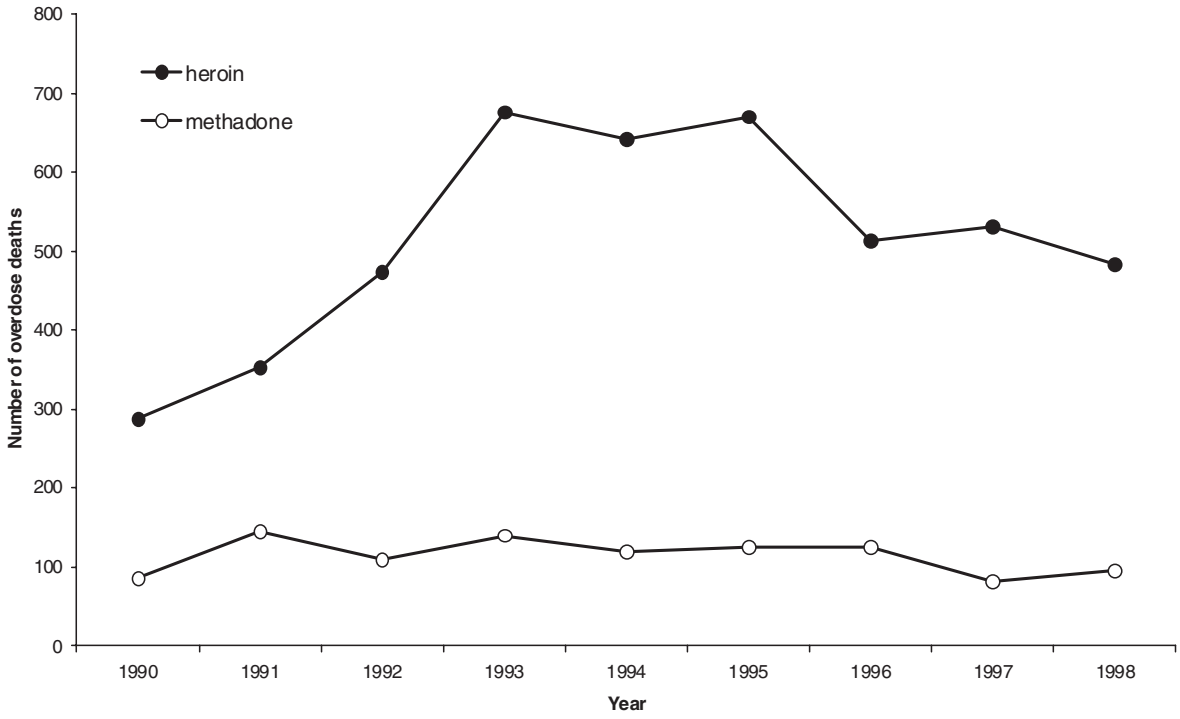

Figure 1 Trends in methadone and heroin overdose deaths in New York City among persons aged 15–64, 1990–1998

Table 1 Bivariate associations with methadone- or heroin-induced overdose death among all accidental drug overdose decedents, New York City, 1990–1998.

	Total overdose deaths		*Methadone-induced overdose deaths*			*Heroin-induced overdose deaths*		
	n	%	*n methadone*	*% methadone*	*P value*	*n heroin*	*% heroin*	*P value*
Total	7451	100.0	1024	13.7		4627	62.1	
Sex								
Female	1531	20.6	310	20.3	<0.001	744	48.6	<0.001
Male	5920	79.5	714	12.1		3883	65.6	
Race/ethnicity								
White	2509	33.7	325	13.0	0.287	1775	70.8	<0.001
Black	2705	36.3	374	13.8		1334	49.3	
Hispanic	2237	30.0	325	14.5		1518	67.9	
Age								
15–24	384	5.2	24	6.3	<0.001	289	75.3	<0.001
25–34	2122	28.5	209	9.9		1427	67.3	
35–44	3234	43.4	525	16.2		2008	62.1	
45–54	1418	19.0	223	15.7		779	54.9	
55–64	293	3.9	43	14.7		124	42.3	
Borough of death								
Manhattan	2444	32.8	325	13.3	0.633	1525	62.4	0.016
Bronx	1726	23.2	257	14.9		1110	64.3	
Brooklyn	1970	26.4	265	13.5		1178	59.8	
Queens	1132	15.2	152	13.4		715	63.2	
Staten Island	179	2.4	25	14.0		99	55.3	
Cocaine detected								
No	2311	31.0	416	18.0	<0.001	1674	72.4	<0.001
Yes	5140	69.0	608	11.8		2953	57.5	
Methadone detected								
No	6039	81.1	N/A			3962	65.6	<0.001
Yes	1412	19.0				665	47.1	
Heroin detected								
No	2569	34.5	542	21.1	<0.001	N/A		
Yes	4882	65.5	482	9.9				
Cannabis detected								
No	6888	92.4	966	14.0	0.014	4228	61.4	<0.001
Yes	563	7.6	58	10.3		399	70.9	
Alcohol detected								
No	4299	57.7	680	15.8	<0.001	2357	54.8	<0.001
Yes	3152	42.3	344	10.9		2270	72.0	
Day of the week								
Monday–Thursday	3007	51.4	396	13.2	0.495	1837	61.1	0.440
Friday–Sunday	2845	48.6	392	13.8		1766	62.1	
Year								
1990	537	7.2	85	15.8	<0.001	287	53.5	<0.001
1991	722	9.7	145	20.1		353	48.9	
1992	788	10.6	109	13.8		473	60.0	
1993	1025	13.8	140	13.7		676	66.0	
1994	981	13.2	119	12.1		641	65.3	
1995	982	13.2	125	12.7		670	68.2	
1996	856	11.5	125	14.6		513	59.9	
1997	808	10.8	81	10.0		531	65.7	
1998	752	10.1	95	12.6		483	64.2	

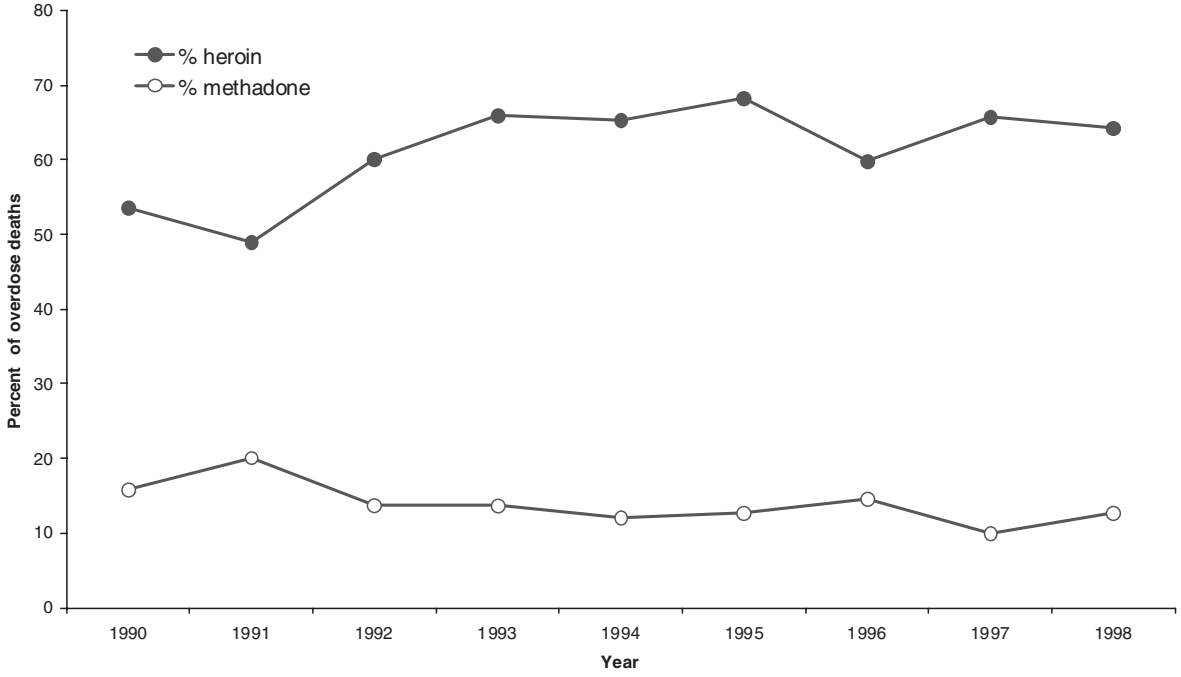

Figure 2 Percentage of accidental overdose deaths caused by heroin and methadone in New York City among persons aged 15–64, 1990–1998

1995 (for trend, $P < 0.001$). The ratio of heroin-induced overdose deaths to methadone-induced overdose deaths varied from a low of 2.4 : 1 in 1991 to a high of 6.6 : 1 in 1997, with an average ratio of 4.6 : 1.

Table 1 also shows the bivariate predictors of accidental overdose death attributed to methadone or heroin, organized by demographic characteristics. Covariates significantly associated with a greater likelihood of methadone-induced overdose death were: female sex (20.3% versus 12.1% for men; $P < 0.001$); older age of the decedent (16.2% for age group 35–44, 15.7% for age 45–54 and 14.7% for age group 55–64 versus 6.3% for age group 15–24 and 9.9% for age group 25–34; $P < 0.001$); absence of cocaine (18% versus 11.8%; $P < 0.001$); absence of heroin (21.1% versus 9.9%; $P < 0.001$); absence of cannabis (14.0% versus 10.3%; $P = 0.014$); absence of alcohol (15.8% versus 10.9%; $P < 0.001$), and earlier year of death (15.0% for 1990, 20.1% for 1991 versus 10.0% for 1997, 12.6% for 1998; $P < 0.001$). Variables significantly associated with heroin-induced overdose death were: male sex of the decedent (65.6% versus 48.6% for women; $P < 0.001$); white or Hispanic race/ethnicity of the decedent (70.8% for white, 67.9% for Hispanic versus 49.3% for black; $P < 0.001$); younger age of the decedent (75.3% for age group 15–24, 67.3% for age group 25–34, 62.1% for age group 35–44 versus 54.9% for age group 45–54, 42.3% for age group 55–64; $P < 0.001$); borough of death ($P = 0.016$); absence of cocaine (72.4% versus 57.5%; $P < 0.001$); absence of methadone (65.6% versus 47.1%; $P < 0.001$); presence of cannabis (70.9% versus 61.4%; $P < 0.001$); presence of alcohol (72.0% versus 54.8%; $P < 0.001$), and later year (53.5% for 1990, 48.9% for 1991 versus 65.7% for 1997, 64.2% for 1998; $P < 0.001$).

Table 2 shows results from multivariate models predicting the likelihood of methadone- or heroin-induced overdose deaths among all accidental overdose deaths. In these multivariate models, the only variable significantly associated with increased risk of methadone-induced overdose death was age [referent: age 15–24 years; age 25–34 odds ratio (OR) = 1.69, 95% confidence interval (CI) = 1.08–2.64; age 35–44 years OR = 3.03, 95% CI = 1.97–4.67; age 45–54 OR = 2.79, 95% CI = 1.78–4.35; age 55–64 OR = 2.34, 95% CI = 1.37–4.01]. Other variables were associated with a significantly decreased risk of methadone-induced deaths: being male (OR = 0.60, 95% CI = 0.52–0.70); presence of cocaine (OR = 0.56, 95% CI = 0.49–0.64); presence of heroin (OR = 0.46; 95% CI = 0.40–0.53), and presence of alcohol (OR = 0.78; 95% CI = 0.68–0.91).

For increased risk of heroin-induced overdose death, variables that were significantly associated in multivariate models were: being male (OR = 1.64, 95% CI = 1.45–1.86); presence of cannabis (OR = 1.28, 95% CI = 1.04–1.56), and presence of alcohol (OR = 1.93, 95% CI = 1.74–2.14). Variables associated with lower risk of heroin-induced overdose death were: being black

Table 2 Multivariate associations with methadone- or heroin-induced overdose death among all accidental drug overdose decedents, New York City, 1990–1998.

	Methadone-induced overdose deaths				*Heroin-induced overdose deaths*			
	Unadjusted		*Adjusted*		*Unadjusted*		*Adjusted*	
	OR	*95% CI*	*OR*	*95% CI*	*OR*	*95% CI*	*OR*	*95% CI*
Sex								
Female	1.00	–	1.00	–	1.00	–	1.00	–
Male	0.54	0.47–0.63	0.60	0.52–0.70	2.02	1.80–2.26	1.64	1.45–1.86
Race/ethnicity								
White	1.00	–			1.00	–	1.00	–
Black	1.08	0.92–1.27			0.40	0.36–0.45	0.49	0.43–0.56
Hispanic	1.14	0.97–1.35			0.87	0.77–0.99	0.87	0.76–1.00
Age								
15–24	1.00	–	1.00	–	1.00	–	1.00	–
25–34	1.64	1.06–2.54	1.69	1.08–2.64	0.68	0.53–0.87	0.72	0.55–0.94
35–44	2.91	1.90–4.44	3.03	1.97–4.67	0.54	0.42–0.69	0.63	0.49–0.82
45–54	2.80	1.81–4.33	2.79	1.78–4.35	0.40	0.31–0.52	0.45	0.34–0.59
55–64	2.58	1.53–4.36	2.34	1.37–4.01	0.24	0.17–0.34	0.29	0.20–0.41
Location								
Manhattan	1.00	–			1.00	–	1.00	–
Bronx	1.14	0.96–1.36			1.09	0.96–1.23	1.07	0.93–1.23
Brooklyn	1.01	0.85–1.21			0.90	0.79–1.01	0.89	0.78–1.02
Queens	1.01	0.82–1.24			1.03	0.89–1.20	0.84	0.71–0.98
Staten Island	1.06	0.68–1.64			0.75	0.55–1.01	0.55	0.40–0.77
Cocaine detected								
No	1.00	–	1.00	–	1.00	–	1.00	–
Yes	0.61	0.53–0.70	0.56	0.49–0.64	0.51	0.46–0.57	0.51	0.46–0.58
Methadone detected								
No	N/A				1.00	–	1.00	–
Yes					0.47	0.42–0.53	0.51	0.45–0.58
Heroin detected								
No	1.00	–	1.00	–	N/A			
Yes	0.41	0.36–0.47	0.46	0.40–0.53				
Cannabis detected								
No	1.00	–	1.00	–	1.00	–	1.00	–
Yes	0.70	0.53–0.93	1.01	0.75–1.35	1.53	1.27–1.85	1.28	1.04–1.56
Alcohol detected								
No	1.00	–	1.00	–	1.00	–	1.00	–
Yes	0.65	0.57–0.75	0.78	0.68–0.91	2.12	1.92–2.34	1.93	1.74–2.14
Day of the week								
Monday–Thursday	1.00	–			1.00	–		
Friday–Sunday	1.05	0.91–1.22			1.04	0.94–1.16		
Year								
1990	1.00	–	1.00	–	1.00	–	1.00	–
1991	1.34	1.00–1.79	1.28	0.94–1.74	0.83	0.67–1.04	0.88	0.70–1.12
1992	0.85	0.63–1.16	0.94	0.69–1.29	1.31	1.05–1.63	1.29	1.02–1.64
1993	0.84	0.63–1.13	0.91	0.67–1.24	1.69	1.36–2.09	1.68	1.34–2.11
1994	0.73	0.54–0.99	0.78	0.57–1.07	1.64	1.33–2.04	1.79	1.43–2.26
1995	0.78	0.58–1.05	0.82	0.61–1.12	1.87	1.51–2.32	2.00	1.58–2.52
1996	0.91	0.67–1.23	0.87	0.64–1.18	1.30	1.05–1.62	1.40	1.10–1.76
1997	0.59	0.43–0.82	0.58	0.42–0.82	1.67	1.34–2.09	1.71	1.34–2.17
1998	0.77	0.56–1.10	0.69	0.50–0.96	1.56	1.25–1.96	1.67	1.32–2.13

(referent: white; OR = 0.49, 95% CI = 0.43–0.56); age (referent: age 15–24 years; age 25–34 years OR = 0.72, 95% CI = 0.55–0.94; age 35–44 OR = 0.63, 95% CI = 0.49–0.82; age 45–54 OR = 0.45, 95% CI = 0.34–0.59; age 55–64 OR = 0.29, 95% CI = 0.20–0.41); location of death (referent: Manhattan; Queens OR = 0.84, 95% CI = 0.71–0.98; Staten Island OR = 0.55, 95% CI = 0.40–0.77); presence of cocaine (OR = 0.51, 95% CI = 0.46–0.58), and presence of methadone (OR = 0.51, 95% CI = 0.45–0.58),

DISCUSSION

In NYC, the number of accidental overdose deaths attributed to methadone stayed relatively constant between 1990 and 1998, averaging 13.9% of the total number of accidental overdose deaths during this time period. The number of heroin-induced overdose deaths rose during the same period, averaging 61.3% of total overdose deaths. The average ratio of heroin-induced overdose deaths compared with methadone-induced overdose deaths was 4.6 : 1 for the period of study. The factors associated with accidental overdose death attributed to methadone or to heroin were different: older age and female sex were predictors of methadone-induced overdose death, while male sex and the presence of either cannabis or alcohol on toxicologic analyses were predictors of heroin-induced overdose deaths.

Commentators in the UK have noted that methadone-induced overdose deaths have risen in recent years disproportionately to the rise in heroin deaths (Cairns *et al.* 1996; Newcombe 1996). However, others have found that methadone- and heroin-induced overdose deaths increased at the same rate: that from the widespread introduction of methadone treatment in the mid-1970s to analyses conducted in the mid-1990s, the methadone-induced overdose death rate did not rise disproportionately compared with concomitant rises in the number of heroin-induced overdose deaths, at least not in the UK (Neeleman & Farrell 1997). Our results, inspired by this controversy but mindful of the differences between the use of methadone in the USA and the UK, build on the work of others who have found that the number of heroin-induced overdose deaths in some locations increased at a significantly higher rate than methadone-induced overdose deaths during the 1990s (Hickman *et al.* 2003). Our results show that methadone-induced overdose deaths fell in NYC during the 1990s, consistent with the observations of some investigators in the UK (Oliver *et al.* 2002). During the period of this study, heroin-induced overdose was responsible for approximately 3–6 times more deaths than was methadone. The absence of an increase in methadone-induced overdose death is particularly noteworthy given that this was a period when the number of people in NYC receiving methadone for the treatment of drug addiction went from 25 795 in 1990 to 33 666 in 1998, an increase of 31% [New York State Office of Alcoholism and Substance Abuse Services (OASAS), personal communication].

We found that methadone-induced overdose death was more likely among women than among men. This finding could be due to a number of factors; for example, this could reflect a disproportionate likelihood of women to request a referral to a methadone maintenance program, as Riley *et al.* (2002) found. This observation merits further research. Our finding that heroin-induced overdose death was more likely among men than among women is consistent with prior research (Darke & Zador 1996). The significantly lower risk of heroin-induced overdose death for blacks found here is not surprising given prior research that has shown that blacks in the USA are more likely to die of a cocaine overdose than from an overdose of other drugs (Harlow 1990; Coffin *et al.* 2003; Galea *et al.* 2003a). We found an increased risk of methadone-induced overdose death among persons over 24, with the highest risk for those aged 35–44 and a decreasing risk of heroin-induced overdose death with age. This probably reflects a decreasing likelihood of active heroin use and an increasing likelihood of enrolment in treatment programs in older age groups (Schutz *et al.* 1994), although this study does not include data on whether those who died from methadone overdose were in a treatment program. Both findings concur with most reports on overdose mortality in the USA, Europe and Australia, where persons in their late twenties and early thirties are generally found to be at highest risk of drug overdose death (Ghodse *et al.* 1998; Hall & Darke 1998; Seal *et al.* 2001; Hickman *et al.* 2003). Finally, the lower likelihood of heroin-induced overdose death in the NYC boroughs of Queens and Staten Island than in the rest of the city is intriguing and deserves additional attention. The degree to which this may reflect different availability of drugs or different patterns of drug use is unknown, but may be worth exploring further using neighborhood-level variables such as poverty and income distribution, which have been considered in earlier studies of accidental drug overdose deaths (Marzuk *et al.* 1997; Galea *et al.* 2003b).

The lower likelihood of methadone-induced overdose death in persons who had positive toxicology for cocaine, heroin or alcohol is important. This finding suggests that in NYC during the period of study, persons dying from a methadone-induced overdose were less likely to be using other drugs concurrently at the time of the overdose. This suggests that methadone-induced overdose decedents in this study were persons using medicinal methadone exclusively rather than street-bought methadone in com-

bination with other drugs. Unfortunately, data from the current study cannot discriminate methadone source or mode of administration, but the lack of polydrug use in those who died from methadone-induced overdose argues against street diversion of methadone. The absence of an association of day of week with rates of methadone deaths also argues against weekend prescribing being associated with greater likelihood of methadone overdose fatality.

Our study has limitations. OCME determinations of cause of death are based on several factors, including (but not limited to) toxicology, making it difficult to determine the relative contributions of methadone and heroin to overdose deaths when both are deemed to contribute to the overdose death by the OCME. The NYC OCME works to ensure consistency in classifying causes of death, but variability among medical examiners and among cases is possible, leading to misclassification of some of the decedents analysed here. We examined methadone-induced overdose in this analysis when it was designated by the OCME as a cause of death. One key limitation is that we had no way of knowing what the source of the methadone was—if it was prescribed by a licensed provider or obtained on the black market—or the form ingested by the deceased, whether liquid or tablets. Data about the drug treatment status of decedents was unavailable to us. However, commentators in Australia have found through meta-analysis that methadone maintenance treatment exerts a protective effect against death from heroin overdose or suicide, with a relative risk for heroin addicts in such programs of 0.25 (95% CI 0.19–0.33) (Caplehorn *et al*. 1996). In addition, the degree to which the results are generalizable outside NYC is unknown. The patterns of opioid use outside NYC, particularly in non-urban areas, may be very different, potentially leading to entirely different trends in overdose mortality. While no increases in methadone deaths were observed in NYC and methadone deaths represent a fraction of overdose deaths overall, there may have been increases in methadone-induced overdose deaths in other locations, as reported in the popular press (Belluck 2003). Finally, we report data until 1998 to allow comparison with recent data reported from the UK. Subsequent trends remain to be analysed. One problem with the time period included in this study is the possibility that methadone prescribed for pain relief may have become a larger portion of the total methadone consumed, potentially affecting trends in mortality due to methadone overdose.

These data indicate no change in the number of overdose deaths attributed to methadone in NYC between 1990 and 1998, even in the presence of increasing heroin-induced overdose deaths during this interval and, more importantly, increases in the prescription of methadone for the treatment of addiction in NYC during this time frame. Methadone death does not appear to be a significant cause of accidental overdose mortality in NYC when compared with heroin, consistent with recent results from the UK.

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