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Research Paper

Unintentional opioid overdose deaths in New York City, 2005–2010: A place-based approach to reduce risk

Anne Siegler*, Ellenie Tuazon, Daniella Bradley O'Brien, Denise Paone

New York City Department of Health and Mental Hygiene, 42-09 28th Street, Long Island City, NY 11101, United States

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ABSTRACT

Background: Drug poisoning is the leading cause of death from injuries in the United States. In New York City (NYC), unintentional drug poisoning death is the third leading cause of premature death, and opioids are the most commonly occurring class of drugs. Opioid overdose prevention efforts aim to decrease the number of people at risk for overdose and to decrease fatality rates among those using opioids by improving overdose response. These strategies can be enhanced with a comprehensive understanding of the settings in which overdoses occur.

Methods: A cross-sectional analysis of unintentional opioid poisoning deaths in NYC from 2005 to 2010 ($n = 2649$). Bivariate and multivariate analyses were performed to identify factors associated with settings of fatal opioid overdose.

Results: Three-quarters of the sample overdosed in a home; one-tenth in an institution, and the remaining in a public indoor setting, the outdoors or another non-home setting. Factors associated with overdosing at home include female gender, college degree, residence in the borough of Staten Island, and combined use of opioid analgesics and benzodiazepines. Factors associated with overdosing outside of the home include ages 35–64, residence in Manhattan, and use of heroin.

Conclusion: The sample represents a near census of unintentional opioid overdose deaths in NYC during the study period, and allows for the identification of demographic and drug-using patterns by setting of overdose. Because most opioid overdoses occur inside the home, opioid overdose response programs can most efficiently address the epidemic by both reducing the risk of overdose in the home and targeting those who may be in the home at the time of an overdose for overdose response training. Approaches include minimizing risk of misuse and diversion through safe storage and safe disposal programs, physician education on prescribing of opioid analgesics and benzodiazepines, prescription of take-home naloxone, and Good Samaritan laws.

Introduction

Poisoning is the leading cause of death from injuries in the United States, surpassing motor vehicle crashes (Warner, Chen, Makuc, Anderson & Miniño, 2011). In New York City (NYC), unintentional drug poisoning death is the third leading cause of premature death (Zimmerman et al., 2013). Drug poisoning deaths involving opioid analgesics have more than tripled nationally since 1999 (Warner, Chen, Makuc, Anderson & Miniño, 2011) and doubled in NYC since 2005 (Bradley O'Brien, Paone, Shah & Heller, 2011). Opioids were involved in nearly three-quarters of all NYC unintentional drug poisoning deaths in 2010 (NYC Department of Health and Mental Hygiene, 2013).

Opioid overdose prevention efforts in the United States can be classified into two primary types: efforts that aim to prevent and decrease the number of individuals at risk of opioid overdose, and efforts that decrease the number of fatal opioid overdoses. Primary prevention efforts include preventing individuals from initiating drug misuse. Other primary prevention efforts aim to prevent the transition of drug misuse to drug dependence among at-risk individuals. Effective overdose prevention strategies include engaging populations at risk in opioid replacement therapy and educating users about behaviors that may put them at risk of opioid overdose. Additional prevention strategies include utilizing Prescription Monitoring Programs (PMP) to reduce risky prescribing of opioid analgesics and benzodiazepines, educating physicians on responsible opioid prescribing practices, and patient education on safe storage and disposal of prescription opioids.

Efforts aimed at decreasing the case fatality rate of opioid overdose are achieved by improving overdose response through

* Corresponding author at: NYC Department of Health and Mental Hygiene, 42-09 28th Street, 19th, Floor – CN14, Long Island City, NY 11101, United States.
Tel.: +1 347 396 7008; fax: +1 347 396 8974.
E-mail addresses: asiegler@health.nyc.gov (A. Siegler), etuazon@health.nyc.gov (E. Tuazon), dbradle1@health.nyc.gov (D. Bradley O'Brien), dpaone@health.nyc.gov (D. Paone).

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strategies such as naloxone distribution to laypersons and first responders (Centers for Disease Control and Prevention, 2012). In addition, Good Samaritan laws aim to increase calls for emergency response to drug overdose by protecting witnesses from arrest for drug possession when calling emergency services.

The identification of opioid overdose settings can aid in the strategic enhancement of opioid overdose prevention efforts. Previous studies have explored drug overdose settings (Bernstein et al., 2007; Bohnert, Tracy & Galea, 2009; Davidson et al., 2003; Cerdá et al., 2013), and have reported varying findings, ranging from 28% (Davidson et al., 2003) to 83% overdosing in private homes (Cerdá et al., 2013). However, these studies did not evaluate if demographics or drug use characteristics were associated with overdose settings. Drug use is a socially and culturally bound phenomenon, making it plausible that an individual's demographic characteristics and the drugs used may in fact affect the setting and risk level of overdosing. The discovery of common opioid overdose settings, as well as any differences by opioid type and demographic characteristics, can help inform the development and implementation of targeted and effective overdose response programs.

Methods

Sample

The sample included all unintentional opioid poisoning deaths among NYC residents aged 15–84 from January 1, 2005 to December 31, 2010, using linked death certificates and medical examiner files. Unintentional drug poisoning death was defined as a death for which the death certificate recorded (i) the manner of death as "accidental," and (ii) the codes for underlying causes of death as "poisoning by a psychoactive substance (excluding alcohol or tobacco)" (ICD-10 codes X40-X44) or a "mental or behavioral disorder due to a psychoactive substance" (ICD-10 codes F11-16, F18-19). The sample was limited to decedents with toxicology results positive for one or more opioids. Methadone was recorded for toxicologies including methadone or methadone metabolite. Heroin was recorded if any of the following were present in toxicology: morphine, 6-monoacetylmorphine (6-MAM), diacetylmorphine, acetylcodeine, morphine and codeine, 6-MAM and codeine, and diacetylmorphine and codeine. Opioid analgesics were recorded if any of the following were present in toxicology: codeine (without heroin), alfentanyl, fentanyl, carfentanyl, sufentanil, hydrocodone, hydromorphone, meperidine, oxycodone, oxymorphone, papavirine, pentazocine, propoxyphene, thebaine, tramadol, or phenacetin.

All manners of death other than unintentional, i.e. intentional, undetermined, or homicide were not included. The sample excluded non-NYC residents and decedents whose borough of residence was unknown or missing. The final analytic sample excluded decedents with missing overdose setting.

Variables and definitions

Demographic variables included gender, race/ethnicity, age, education, borough of residence, and neighborhood poverty. Race/ethnicity included non-Hispanic white, non-Hispanic black, Hispanic, and Non-Hispanic other, which collapsed other race/ethnicities and missing. Age was categorized as 15–24, 25–34, 35–44, 45–54, 55–64, and 65–84 years. Education level was determined from the death certificate and defined as less than high school, completed high school or General Education Development exam, some college, and college or more. Neighborhood poverty was defined from United Hospital Fund area (UHF, an aggregation of zip codes averaging nearly 200,000 population) of residence, as the percent of residents with incomes below 100% of the Federal Poverty Level per American Community Survey and Census 2000. Neighborhood poverty was categorized into four groups: low (<10% of residents below poverty), medium (10% to <20% below poverty), high (20% to <30% below poverty), and very high (≥30% below poverty).

Settings of overdose were abstracted from medical examiner files as a text field and categorized into five groups. The decedent's home or others' homes were collapsed into the category home. Home was defined as a non-staffed residential address, including independent apartments, houses, and public housing. Staffed residences such as homeless shelters and supportive housing facilities were not included in the 'home' category. Other locations were classified as non-home, and stratified into four sub-groups: institutional residences, public indoors, outdoors, and other. Institutional residences included homeless shelters, single room occupancies, supportive housing, nursing homes, and assisted living facilities. Public indoor settings included bars, restaurants, hotels, public bathrooms, offices, building lobbies, elevators, and stairways. Outdoors included parks, streets, roofs, cars, buses, and subways. The setting category other included prison, drug treatment programs, and hospitals.

Drugs and drug metabolites were abstracted from toxicology reports of medical examiner files, and included alcohol, benzodiazepines, cocaine, methadone, heroin, and opioid analgesics. Given the large number of patients in methadone maintenance in NYC, methadone is reported separately from other opioid analgesics. Drugs were not mutually exclusive; a decedent's toxicology could be positive for more than one drug. In addition to single drug classifications, four drug combinations were analyzed: heroin and opioid analgesics, heroin and methadone, methadone and opioid analgesics, and opioid analgesics and benzodiazepines.

Data analysis

A descriptive analysis of demographics and drug types was conducted for the total sample and for subsamples by setting. All drugs and drug combinations were analyzed as dummy variables. Age-adjusted rates were calculated for demographics and drug types, while age-standardized rates were calculated for each age group. Rates were age-adjusted to Census 2000. To obtain aggregate rates across six years, age-adjusted rates were averaged.

Logistic regression was used to compare characteristics of those who overdosed at home to those who overdosed elsewhere. Interactions were tested between demographics and between each drug. Multivariate logistic regression using backward selection was conducted to determine predictors of overdose settings. All variables significant at 0.05 were kept in the final model. Adjusted odds ratios and corresponding 95% confidence intervals were computed, and model fit was evaluated. All analyses were conducted using SAS 9.2 (Cary, NC).

Results

From 2005 to 2010, there were 4083 unintentional drug overdose deaths in NYC. The greatest number of unintentional drug poisoning deaths occurred in 2006 ($n = 838$) and decreased each subsequent year to a low of 541 in 2010 (data not presented). A total of 1434 decedents did not meet inclusion criteria (criteria were not mutually exclusive and could overlap): 1126 decedents did not test positive for any opioids, 179 were not NYC residents, 127 were missing borough of residence, and 53 were missing setting of overdose. The final analytic sample was comprised of 2649 decedents. Proportions of overdoses by setting did not change significantly over the study period, so all years were collapsed. There

Table 1
Unintentional opioid overdose deaths by setting of overdose: Home versus 'non-home', New York City, 2005–2010.

	Total			Setting of overdose[a]						Unadjusted OR (95% CI)[e]	*p*-value	Adjusted OR (95% CI)[f]	Types of 'non home' settings									
				Overdosed at home									Institution			Public Indoors			Outdoors			Other		
				Yes			No																	
	N	%[b]	AAR[c]	*N*	%[b]	%[d]	*N*	%[b]	%[d]				*N*	%[b]	%[g]	*N*	%[b]	%[g]	*N*	%[b]	%[g]	*N*	%[b]	%[g]
Total	2649	100.0	6.8	2000	100.0	76.0	632	100.0	24.0				268	100.0	42.4	181	100.0	28.6	162	100.0	25.6	21	100.0	3.3
Gender																								
Male	1954	73.8	10.5	1426	71.3	73.0	516	81.6	26.4	*Ref*	*Ref*	*Ref*	217	81.0	42.1	144	79.6	27.9	140	86.4	27.1	15	71.4	2.9
Female	695	26.2	3.8	574	28.7	82.6	116	18.4	16.7	**1.79 (1.43, 2.24)**	**<.0001**	**1.68 (1.31, 2.16)**	51	19.0	44.0	37	20.4	31.9	22	13.6	19.0	6	28.6	5.2
Race/Ethnicity																								
Non-Hispanic Black	573	21.6	5.9	399	20.0	69.6	169	26.7	29.5	**0.59 (0.47, 0.74)**	**<.0001**	*NS*[k]	86	32.1	50.9	33	18.2	19.5	42	25.9	24.9	8	38.1	4.7
Non-Hispanic White	1224	46.2	9.3	973	48.7	79.5	243	38.4	19.9	*Ref*	*Ref*		91	34.0	37.4	82	45.3	33.7	60	37.0	24.7	10	47.6	4.1
Hispanic	783	29.6	7.6	583	29.2	74.5	197	31.2	25.2	**0.74 (0.60, 0.92)**	**0.0057**	*NS*	76	28.4	38.6	60	33.1	30.5	58	35.8	29.4	3	14.3	1.5
Non-Hispanic Other	69	2.6	–	45	2.3	65.2	23	3.6	33.3				15	5.6	65.2	6	3.3	26.1	2	1.2	8.7	0	0.0	0.0
Age, years[h]																								
15–24	152	5.7	2.2	132	6.6	86.8	18	2.8	11.8	*Ref*	*Ref*	*Ref*	4	1.5	22.2	6	3.3	33.3	7	4.3	38.9	1	4.8	5.6
25–34	414	15.6	5.1	325	16.3	78.5	86	13.6	20.8	**0.52 (0.30, 0.89)**	**0.0175**	0.59 (0.33, 1.07)	20	7.5	23.3	40	22.1	46.5	24	14.8	27.9	2	9.5	2.3
35–44	712	26.9	9.9	527	26.4	74.0	181	28.6	25.4	**0.40 (0.24, 0.67)**	**0.0005**	**0.40 (0.23, 0.70)**	66	24.6	36.5	55	30.4	30.4	51	31.5	28.2	9	42.9	5.0
45–54	948	35.8	14.5	704	35.2	74.3	239	37.8	25.2	**0.40 (0.24, 0.67)**	**0.0005**	**0.47 (0.27, 0.80)**	116	43.3	48.5	56	30.9	23.4	60	37.0	25.1	7	33.3	2.9
55–64	382	14.4	7.5	282	14.1	73.8	97	15.3	25.4	**0.40 (0.23, 0.68)**	**0.0009**	**0.48 (0.27, 0.86)**	57	21.3	58.8	22	12.2	22.7	16	9.9	16.5	2	9.5	2.1
65–84	39	1.5	0.8	29	1.5	74.4	10	1.6	25.6	**0.40 (0.17, 0.95)**	**0.0369**	0.48 (0.18, 1.32)	5	1.9	50.0	1	0.6	10.0	4	2.5	40.0	0	0.0	0.0
Education																								
Less than high school	637	24.0	–	477	23.9	74.9	156	24.7	24.5	*Ref*	*Ref*	*Ref*	51	19.0	32.7	60	33.1	38.5	42	25.9	26.9	3	14.3	1.9
High school graduate or GED	1238	46.7	–	941	47.1	76.0	287	45.4	23.2	1.07 (0.86, 1.34)	0.5412	1.13 (0.90, 1.43)	115	42.9	40.1	78	43.1	27.2	80	49.4	27.9	14	66.7	4.9
Some college	239	9.0	–	193	9.7	80.8	45	7.1	18.8	1.40 (0.97, 2.03)	0.0742	1.34 (0.91, 1.98)	20	7.5	44.4	12	6.6	26.7	13	8.0	28.9	0	0.0	0.0
College or more	305	11.5	–	263	13.2	86.2	41	6.5	13.4	**2.10 (1.44, 3.05)**	**0.0001**	**2.13 (1.44, 3.16)**	18	6.7	43.9	15	8.3	36.6	7	4.3	17.1	1	4.8	2.4
Missing/unknown	230	8.7	–	126	6.3	54.8	103	16.3	44.8				64	23.9	62.1	16	8.8	15.5	20	12.3	19.4	3	14.3	2.9
Borough of residence																								
Manhattan	517	19.5	6.4	346	17.3	66.9	166	26.3	32.1	**0.68 (0.53, 0.87)**	**0.002**	**0.69 (0.52, 0.91)**	93	34.7	56.0	43	23.8	25.9	26	16.0	15.7	4	19.0	2.4
Bronx	655	24.7	10.6	504	25.2	76.9	148	23.4	22.6	1.11 (0.87, 1.41)	0.4203	1.32 (1.00, 1.73)	69	25.7	46.6	31	17.1	20.9	45	27.8	30.4	3	14.3	2.0
Brooklyn	784	29.6	6.7	588	29.4	75.0	191	30.2	24.4	*Ref*	*Ref*	*Ref*	74	27.6	38.7	57	31.5	29.8	53	32.7	27.7	7	33.3	3.7
Queens	465	17.6	4.3	366	18.3	78.7	96	15.2	20.6	1.24 (0.94, 1.64)	0.1313	1.10 (0.81, 1.48)	22	8.2	22.9	41	22.7	42.7	28	17.3	29.2	5	23.8	5.2
Staten Island	228	8.6	10.6	196	9.8	86.0	31	4.9	13.6	**2.05 (1.36, 3.10)**	**0.0006**	**1.71 (1.10, 2.67)**	10	3.7	32.3	9	5.0	29.0	10	6.2	32.3	2	9.5	6.5
Neighborhood poverty[i]																								
Low (<10% below poverty)	213	8.0	4.8	175	8.8	82.2	38	6.0	17.8	**1.86 (1.28, 2.71)**	**0.0012**	*NS*	17	6.3	44.7	12	6.6	31.6	7	4.3	18.4	2	9.5	5.3
Medium (10 to <20%)	910	34.4	5.4	708	35.4	77.8	196	31.0	21.5	**1.46 (1.18, 1.80)**	**0.0004**	*NS*	64	23.9	32.7	70	38.7	35.7	55	34.0	28.1	7	33.3	3.6
High (20 to <30%)	487	18.4	6.4	385	19.3	79.1	98	15.5	20.1	**1.59 (1.22, 2.06)**	**0.0005**	*NS*	30	11.2	30.6	28	15.5	28.6	36	22.2	36.7	4	19.0	4.1
Very high (≥30%)	1022	38.6	10.6	723	36.2	70.7	292	46.2	28.6	*Ref*	*Ref*		156	58.2	53.4	66	36.5	22.6	64	39.5	21.9	6	28.6	2.1
Drug type[j]																								
Opioids																								
Methadone (any)	1050	39.6	2.7	788	39.4	75.0	251	39.7	23.9	0.99 (0.82, 1.19)	0.8875		128	47.8	51.0	55	30.4	21.9	54	33.3	21.5	14	66.7	5.6
Heroin (any)	1659	62.6	4.2	1201	60.1	72.4	449	71.0	27.1	**0.61 (0.51, 0.74)**	**<.0001**	**0.76 (0.61, 0.95)**	174	64.9	38.8	144	79.6	32.1	120	74.1	26.7	11	52.4	2.4
Opioid analgesics (any)	799	30.2	2.1	655	32.8	82.0	131	20.7	16.4	**1.91 (1.54, 2.36)**	**<.0001**	*NS*	61	22.8	46.6	38	21.0	29.0	28	17.3	21.4	4	19.0	3.1

Table 1 (*Continued*)

	Total			Setting of overdose[a]						Unadjusted OR (95% CI)[e]	*p*-value	Adjusted OR (95% CI)[f]	Types of 'non home' settings									
				Overdosed at home									Institution			Public Indoors			Outdoors			Other		
				Yes			No																
	N	%[b]	AAR[c]	*N*	%[b]	%[d]	*N*	%[b]	%[d]				*N*	%[b]	%[g]	*N*	%[b]	%[g]	*N*	%[b]	%[g]	*N*	%[b]	%[g]
Heroin and opioid analgesics	273	10.3	0.7	212	10.6	77.7	59	9.3	21.6	1.15 (0.85, 1.56)	0.3622		30	11.2	50.8	20	11.0	33.9	7	4.3	11.9	2	9.5	3.4
Heroin and methadone	464	17.5	1.2	340	17.0	73.3	120	19.0	25.9	0.87 (0.69, 1.10)	0.2517		56	20.9	46.7	32	17.7	26.7	27	16.7	22.5	5	23.8	4.2
Methadone and opioid analgesics	192	7.2	0.5	153	7.7	79.7	39	6.2	20.3	1.26 (0.88, 1.81)	0.2136		22	8.2	56.4	7	3.9	17.9	8	4.9	20.5	2	9.5	5.1
Cocaine (any)	1314	49.6	3.4	995	49.8	75.7	310	49.1	23.6	1.03 (0.86, 1.23)	0.7592		125	46.6	40.3	85	47.0	27.4	91	56.2	29.4	9	42.9	2.9
Benzodiazepines (any)	1058	39.9	2.7	833	41.7	78.7	219	34.7	20.7	**1.35 (1.12, 1.62)**	**0.0018**	*NS*	86	32.1	39.3	69	38.1	31.5	53	32.7	24.2	11	52.4	5.0
Alcohol (any)	1143	43.1	2.9	861	43.1	75.3	279	44.1	24.4	0.96 (0.80, 1.15)	0.6275		124	46.3	44.4	74	40.9	26.5	77	47.5	27.6	4	19.0	1.4
Heroin and benzodiazepines	579	21.9	1.5	434	21.7	75.0	188	29.7	32.5	0.95 (0.77, 1.17)	0.6236		56	20.9	29.8	46	25.4	24.5	36	22.2	19.1	5	23.8	2.7
Methadone and benzodiazepines	460	17.4	1.2	348	17.4	75.7	109	17.2	23.7	1.01 (0.80, 1.28)	0.9295		52	19.4	47.7	29	16.0	26.6	20	12.3	18.3	8	38.1	7.3
Opioid analgesics and benzodiazepines	422	15.9	1.1	369	18.5	87.4	51	8.1	12.1	**2.58 (1.90, 3.51)**	**<.0001**	**1.92 (1.36, 2.71)**	19	7.1	37.3	18	9.9	35.3	12	7.4	23.5	2	9.5	3.9

[a] Home includes one's own home and someone else's home; institution includes nursing home, assisted living, supporting housing, shelter, SRO; public indoors includes bar, restaurant, hotel, office, public bathroom, building lobby, elevator, stairwell; outdoors includes public transportation, street, park, abandoned building, roof; other includes prison, drug treatment programs, and hospitals.

[b] Column percent.

[c] AAR: age-adjusted rate. Age-adjusted rates reported per 100,000 residents averaged across years 2005–2010. Rates are calculated using intercensal New York City population denominators updated July 2013, and are weighted to New York City population Census 2000.

[d] Row percent of total overdose decedents ($N = 2649$).

[e] OR: odds ratio. CI: Confidence Interval. OR's model setting of death as outcome (home vs. not home). OR > 1 indicates greater odds of overdosing at home; OR < 1 indicates greater odds of overdosing not at home.

[f] Model excludes variables not significant at $p < .05$ level. Final model adjusted for gender, race, education, borough of residence, heroin, opioid analgesics, benzodiazepines, and the interaction of opioid analgesics and benzodiazepines. Adjusted odds ratio (AOR) > 1 indicates greater odds of overdosing at home; AOR < 1 indicates greater odds of overdosing not at home.

[g] Row percent of total overdose decedents with 'not home' overdose settings ($N = 632$).

[h] Rates for age groups reported as age-standardized rates (ASR).

[i] Neighborhood poverty (based on UHF) defined as percent of residents with incomes below 100% of the Federal Poverty Level per American Community Survey Census 2000.

[j] Drug types are not mutually exclusive, thus will not add to 100%.

[k] NS: not significant at $p < .05$ level, fell out of final model using backwards elimination.

were no significant demographic differences among the four categories of non-home overdoses, and these were collapsed into one "not home" category for statistical analysis (Table 1).

Approximately three-quarters of the sample (74% or 1954) were males, having an age-adjusted mortality rate nearly three times that of females. Slightly less than half of the sample ($n = 1224$) were non-Hispanic whites, less than one-third ($n = 783$) were Hispanic, and approximately one-fifth ($n = 573$) were non-Hispanic black. Whites had the highest age-adjusted mortality rate. Decedents' ages ranged from 15 to 82, with a median age of 45 years. Individuals with the highest overdose mortality rate were those aged 45–54 years. Two-thirds of the sample (67% or 1782) had a high school diploma or more education. While the largest proportion of decedents lived in the borough of Brooklyn (30% or 784), the Bronx and Staten Island had the highest age-adjusted mortality rates. Over one-third of the decedents (39% or 1022) came from neighborhoods with very high poverty levels. As neighborhood poverty increased, rates of overdose mortality increased as well, with very high poverty neighborhoods having more than double the rates of low poverty neighborhoods.

When stratifying by setting of overdose, three-quarters of the analytic sample (2000) overdosed at home. Of these decedents, approximately 89% (1770) overdosed in their own home and the remainder overdosed in others' homes. There were 632 decedents who overdosed outside of the home. Of these decedents, 42% ($n = 268$) overdosed in an institutional residence, followed by 29% in a public indoor setting, 26% in an outdoor setting, and 3% in other settings ($n = 181$, $n = 162$, and $n = 21$, respectively).

Among each demographic group, the majority of overdoses occurred in the home. In bivariate analysis, female gender was associated with overdosing in the home, compared to male gender (OR 1.79). Non-Hispanic black and Hispanic races were associated with overdosing outside of the home (OR 0.59 and 0.74, respectively). Decedents aged 25–84 were more likely to overdose outside of the home compared to individuals under 25 (ORs from 0.40 to 0.52). College-educated individuals had twice the risk of overdosing at home compared to individuals without a high school diploma (OR 2.10). Compared to residents of Brooklyn, residents of Manhattan were more likely to overdose outside of the home (OR 0.68), while residents of Staten Island were more likely to overdose inside the home (OR 2.05). Compared to individuals who live in neighborhoods with very high poverty rates, individuals in wealthier neighborhoods are more likely to overdose at home (ORs from 1.46 to 1.86). No significant interactions were observed when age and education were tested with other demographic variables.

Heroin was the most common opioid in overdoses among all settings and involved in 63% of all overdoses. Heroin also had the highest age-adjusted mortality rate among all single drug types and drug combinations. Cocaine and alcohol were the second and third most common substances in all settings except institutions, involved in 50% and 43% of all overdoses overall, respectively. In institutional residences, methadone was the second most common drug after heroin, involved in 48% of institution overdose deaths, and cocaine was the third most common, involved in 47%. Benzodiazepines were most commonly found in combination with opioid analgesics (benzodiazepines were in 53% of opioid analgesic-related deaths), and also were found in combination with methadone (44%) and heroin (35%) (data not presented). The most common combination of drugs in overdoses occurring at home was opioid analgesics and benzodiazepines, whereas in all other non-home settings, heroin and methadone was the most common drug combination. In bivariate analysis, heroin was significantly associated with overdosing outside of the home (OR 0.61). Opioid analgesics, benzodiazepines, and combined opioid analgesics with benzodiazepines were significantly associated with overdosing inside the home (ORs 1.91, 1.35, 2.58, respectively).

In a multivariate analysis, after adjusting for significant demographics and drug types, gender, age, education, borough of residence, as well as the drug types heroin and combined use of opioid analgesics and benzodiazepines remained significant predictors of overdose setting. Females, college graduates, and residents of Staten Island had significantly greater odds of overdosing at home compared to males (AOR 1.68), individuals who did not complete high school (AOR 2.13), and residents of Brooklyn (AOR 1.71). Residents of Manhattan had lower odds of overdose at home compared to residents of Brooklyn (AOR 0.69), as did individuals ages 35–64 compared to those ages 15–24 (AORs 0.40–0.48). Decedents who overdosed on heroin were less likely to overdose at home, compared to decedents who had not used heroin (AOR 0.76). Concurrent use of opioid analgesics and benzodiazepines nearly doubled the odds of overdosing at home compared to decedents with neither or only one of these medications (AOR 1.92). Of note, neither opioid analgesics nor benzodiazepines alone were significantly associated with overdose setting, after controlling for demographic characteristics.

Discussion

We found that three-quarters of unintentional drug poisoning deaths occurred inside the home, which is consistent with the highest estimates in the NYC literature (Cerdá et al., 2013) and higher than the proportions found in other locations such as San Francisco (Davidson et al., 2003) and New South Wales, Australia (Darke, Ross, Zador & Sunjic, 2000). Our study further identified that female gender, college education, Staten Island residence, and combined opioid analgesic/benzodiazepine were significantly associated with overdosing at home. In contrast, ages 35–64 (compared to ages 15–24), residence in Manhattan, and heroin use were associated with overdosing outside of the home. Despite these findings, fatal overdoses were more likely to occur in the home than elsewhere for every demographic group and drug type.

Because most opioid overdoses occur inside the home, opioid overdose response programs can most efficiently address the epidemic by both reducing the risk of overdose in the home and targeting those who may be in the home at the time of an overdose for overdose response training. To reduce risks in the home, programs that minimize opportunities for misuse and diversion of opioids such as safe storage and safe disposal of opioid analgesics should be encouraged. Physician awareness can be raised regarding the risks of overdose and physicians should be encouraged to utilize PMP to review patient histories and reduce risky prescribing practices of opioid analgesics and benzodiazepines. Patient awareness can be raised regarding the risks of polydrug use, particularly opioids with benzodiazepines.

To prepare potential witnesses of opioid overdose, legal take-home naloxone, prescribed by a medical professional for use by a trained layperson, is a key element of effective response. Layperson administration of naloxone was legalized in New York State in 2006 and utilization of naloxone by community members to reverse opioid overdose occurred throughout the study period in NYC. One way of increasing the availability of naloxone is through co-prescription of naloxone with opioid analgesics, for safe-keeping in patients' medicine cabinets. Calling emergency services when a person overdoses is another critical element of effective response. Rates of calling may be improved by protecting callers from arrest for drug possession. A Good Samaritan law offers this protection and in New York was passed after the study period ended, in 2011. Good Samaritan laws would make little difference, if, for example, the majority of overdoses occurred in institutions, where staff were trained to call emergency services and would not fear arrest, underscoring the importance of understanding overdose setting and the ways in which setting has implications for policy.

While home was the most common setting for opioid overdose deaths, a substantial proportion of overdoses did, however, occur outside of the home, most commonly in institutional residences. Overdoses occurring in institutions most commonly involved heroin or methadone. For this reason, overdose prevention efforts located in institutions such as homeless shelters, supportive housing facilities, and SRO's, should target both heroin and methadone users. Interventions could include training institution staff and residents in first aid and naloxone administration, instituting policies that minimize risk for fatal overdose such as medication storage policies, and educating institution residents on reducing overdose risk and recognizing opioid overdose symptoms.

We were unable to discern whether differences in setting of overdose by drug type reflect differences in drug use patterns or an interaction between drug type and setting. We hypothesize that the risk for unintentional overdose in a particular setting may vary by drug type or drug user characteristics. Heroin use, for example, may be riskier outside of the home because the user has less control of the environment and may fear arrest, as previous studies have found (Bohnert et al., 2011; Kerr, Small, Moore & Wood, 2007) while opioid analgesic and benzodiazepine use may be riskier inside the home, where opportunities for bystander rescue may be slimmer.

Our study has several limitations in addition to those already discussed. By excluding all decedents with missing boroughs of residence, we may be systematically excluding homeless individuals who may be more likely to overdose in settings such as institutions or outdoors. Decedents with missing residential information, however, comprised less than 5% of the total sample and would contribute minimal selection bias. Setting of overdose may be subject to misclassification bias if some research staff coded settings differently than others, but duplicate recording and validation efforts were undertaken to minimize this risk. Our study was not able to assess the proportion of overdoses that were witnessed, which is a necessary precondition for successful intervention. Future research will need to determine this proportion in order to confirm and capitalize on the findings of this study and its implications for policy. Last, it is possible that had we analyzed more than six years of data, we would have identified variations in setting of overdose over time, thus, reporting findings by year rather than in aggregate.

Despite these limitations, this study has several strengths. The NYC Office of the Chief Medical Examiner is responsible for investigating all deaths believed to be homicides, suicides or accidents; deaths of a suspicious unnatural nature; and deaths not attended by a physician. Drug overdose deaths often fall within these parameters. Thus the study sample, we believe, is a near census of the population of overdose decedents in NYC during this time period. The large sample size allows patterns to emerge within settings and demographic and drug-using categories. We had the unique opportunity to link death certificate information with biomarkers from medical examiner records, offering greater validity of toxicological information beyond those written in 'cause of death' death certificate fields.

Regardless of the demographic subgroup or what drug was positive in toxicology, the majority of unintentional opioid overdoses occurred in the home. By both reducing risks in the home and training friends and family members to respond to overdoses, it is possible to reduce the number of fatal opioid overdoses in the home and make home a safer place. While mortality due to opioid analgesic overdose continues to increase both in NYC and nationally, attention is turning to potential prevention strategies. Interventions that aim to reduce overdose mortality can maximize their success by using this study's findings to focus on preventing fatal overdoses in the home.

Conflict of interest statement

None declared.

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