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Unintentional drug overdose death trends in New Mexico, USA, 1990–2005: combinations of heroin, cocaine, prescription opioids and alcohol

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ABSTRACT

Aims To determine the contribution of heroin, prescription opioids, cocaine and alcohol/drug combinations to the total overdose death rate and identify changes in drug overdose patterns among New Mexico subpopulations. **Design** We analyzed medical examiner data for all unintentional drug overdose deaths in New Mexico during 1990–2005. Age-adjusted drug overdose death rates were calculated by sex and race/ethnicity; we modeled overall drug overdose death adjusting for age and region. **Findings** The total unintentional drug overdose death rate in New Mexico increased from 5.6 per 100 000 in 1990 to 15.5 per 100 000 in 2005. Deaths caused by heroin, prescription opioids, cocaine and alcohol/drug combinations together ranged from 89% to 98% of the total. Heroin caused the most deaths during 1990–2005, with a notable rate increase in prescription opioid overdose death during 1998–2005 (58%). During 1990–2005, the 196% increase in single drug category overdose death was driven by prescription opioids alone and heroin alone; the 148% increase in multi-drug category overdose death was driven by heroin/alcohol and heroin/cocaine. Hispanic males had the highest overdose death rate, followed by white males, white females, Hispanic females and American Indians. The most common categories causing death were heroin alone and heroin/alcohol among Hispanic males, heroin/alcohol among American Indian males and prescription opioids alone among white males and all female subpopulations. **Conclusions** Interventions to prevent drug overdose death should be targeted according to use patterns among at-risk subpopulations. A comprehensive approach addressing both illicit and prescription drug users, and people who use these drugs concurrently, is needed to reduce overdose death.

Keywords Alcohol, cocaine, drug, overdose, heroin, medical examiner, opioids, surveillance.

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INTRODUCTION

Historically, a high prevalence of drug use has been observed in New Mexico [1,2]. New Mexico led the United States in unintentional and undetermined overdose deaths in 2003 with a death rate of 17.5 per 100 000, during which time the national rate was 7.5 deaths per 100 000, and four New Mexico counties were among the top 25 US counties during 2001–03 [3]. Heroin in New Mexico, almost exclusively black tar and brown, has caused the most unintentional overdose deaths. Given the extent of illicit drug use and its consequences, public health efforts such as publicly funded syringe exchange and training in naloxone administration have been implemented and are ongoing, yet unintentional drug overdose death rates continue to rise.

Unintentional drug overdose remains a primary cause of illness and premature death among illicit drug users world-wide [4–10]. In 2005, an estimated 19.7 million Americans aged 12 years or older were current illicit drug users, representing 8.1% of the population [11]. The 2005 rate of current illicit drug use in the United States was similar to the rate in 2004 (7.9%), 2003 (8.2%) and 2002 (8.3%). Even though national estimates of drug use prevalence have not changed over the last few years, rates of overdose death have been increasing in the

United States [12]. Factors that may contribute to excess drug overdose death range from individual factors such as multi-drug use [13–16], drug injection administration [17,18] and loss of tolerance [19–21], to contextual/social factors such as using in public locations [22], using alone and with people who may be less likely to call for help [23,24], to deteriorating environment [25] and increased drug purity [26].

The study of overdose death patterns over time may help to explain the factors that impact trends in overall drug overdose death among a population. Coffin *et al.* [16] provided evidence that changes in multi-drug overdose death from opiates, cocaine and alcohol accounted for most of the change in total overdose death rates in New York City (NYC) during 1990–98. They also demonstrated that overdose death trends among subpopulations reflected the varying drug combination overdose deaths within those groups. Using similar methods, we analyzed medical examiner records for all unintentional drug overdose deaths from 1990 to 2005 in order to (i) gain a better understanding of the extent to which drug combinations contribute to the unintentional overdose death rate over time; and (ii) identify changes in drug overdose death patterns among gender and racial/ethnic groups. In addition to heroin, cocaine and alcohol/drug combinations, we also examined prescription opioids, given the growing role of these drugs among unintentional drug overdose deaths in New Mexico [27,28]. A comprehensive investigation of illicit and prescription drug overdose death by demographics could provide a solid foundation from which to target prevention programs and interventions among subpopulations.

METHODS

All cases of unintentional drug overdose death were identified in New Mexico from 1990 to 2005 using an electronic database provided by the Office of the Medical Investigator (OMI). OMI is authorized to investigate all deaths in New Mexico that are sudden, unexplained, suspicious, violent or unattended, with the exception of those that occur on federal or tribal jurisdictions. However, OMI is often contracted to investigate some of those deaths as well. For all deaths suspected of being due to the effect of drugs or poisons, a full autopsy is carried out, samples are screened for drugs of abuse and those with positive results are confirmed with additional tests. OMI pathologists consult with toxicologists in case evaluations. When individuals die from toxic substances after a period of hospitalization OMI procures antemortem specimens, when available, from the health-care facility for toxicological testing.

Classification for cause of death is determined by OMI board-certified forensic pathologists and is not simply a determination of the presence or absence of a drug in a toxicological screen. The diagnosis of a drug overdose death is dependent on the autopsy, circumstances of death, scene investigation, medical records and blood concentration levels of one or more drugs, either with or without alcohol, as determined by the pathologist. Accordingly, pathologists classify manner of death based on information from the full investigation.

The main metabolites for heroin and morphine are similar. In order to distinguish heroin overdose death from prescription morphine overdose death, heroin-caused overdose death is diagnosed by the presence of 6-monoacetylmorphine (6-MAM) and/or morphine, in combination with information from the OMI investigation. In general, a heroin-caused death is diagnosed when a lethal blood concentration level for 6-MAM is found. When a morphine blood concentration level is found without the presence of 6-MAM, OMI may conclude that heroin is the cause of overdose death after considering all available information (i.e. syringe/heroin at scene, track marks, history of heroin use). The finding of a morphine blood concentration in a decedent is classified as a morphine-caused death if the differentiation between heroin- and morphine-caused death is not definitive.

Statistical analyses and covariates

Analyses included unintentional drug overdose decedents who were residents of and died in New Mexico from 1990 to 2005 ($n = 2954$). Five per cent ($n = 136$) of decedents were missing data for the drug(s) that caused death and were excluded. The total number and rates of unintentional drug overdose deaths were calculated for each year of the study period and for the primary drugs causing overdose death in New Mexico, namely heroin, prescription opioids (methadone, oxycodone, hydrocodone, propoxyphene, fentanyl, morphine, codeine, meperidine, hydromorphone), cocaine and alcohol in combination with drugs. This analysis does not describe other less common drugs that caused overdose death. One-year and 2-year death rates from heroin, prescription opioids, cocaine and alcohol/drug combinations were also calculated by sex and the three largest racial/ethnic groups in New Mexico: non-Hispanic white, Hispanic white and American Indian (subsequently referred to as white, Hispanic and American Indian). Death rates among American Indians were not shown for some analyses due to a small number of events. Death rates were expressed per 100 000 person-years and age-adjusted to the 2000 US standard population.

For the purpose of this analysis, single drug category overdose was death caused by one of the four drug categories and multi-drug category overdose was death caused by at least two categories. It is important to note that while

heroin, cocaine and alcohol were single categories of a drug, the category of prescription opioids included multiple drugs. Specific categories of drugs were first examined as causing death either alone or in combination with other drug categories (not mutually exclusive), and then unique combinations of categories were analyzed and presented in descending order of the most frequently observed combinations. Annual death rates were also calculated for overdose from single and multiple drugs, where drugs in the category of prescription opioids were counted as single drugs alongside heroin, cocaine and alcohol. For instance, death caused by methadone and oxycodone was coded as a multi-drug overdose death.

Population denominators for rate calculations were bridged-race census/intercensal estimates for 1990–99, a collaboration of the US Census Bureau and the National Center for Health Statistics [29]. State population estimates for 2000–05 were generated by the Bureau of Business and Economic Research (BBER), University of New Mexico. It is believed that the US Census Bureau population estimate for New Mexico is an undercount, due to the methodology based upon raking processes for a national control total. The BBER evaluates all input data and employs a housing unit-based methodology, validated by building permits and birth/death records, which is believed to result in a more accurate population estimate for New Mexico.

Lastly, a regression model was examined for overall overdose death rates. The model was tested for overdispersion and fitted as a log-linear regression (i.e. log link and Poisson distribution) with an offset equal to the natural logarithm of person-years. The overall model fit was assessed using deviance test statistics and residuals, and was found appropriate. The covariate effects were expressed as incidence rate ratios (RR) or relative risks, with 95% confidence intervals (95% CI).

RESULTS

There were 2954 unintentional drug overdose deaths among New Mexico residents between 1990 and 2005. Ninety-five per cent ($n = 2818$) of decedents had data for the drug(s) causing death and were included in this analysis. The median age was 40.0 years (1st, 3rd interquartile range: 32.7, 46.6) and the majority were male (77.0%). More than half of decedents were Hispanic (54.7%), 39.9% were white and 2.6% were American Indian. Nearly half of decedents (47.4%) resided in the Albuquerque area, with north-eastern New Mexico (19.9%) being the second most common region of residence. Death was caused by heroin for 50.0% of decedents (ranging from 36.4% in 2003 to 68.7% in 1995), prescription opioid for 33.9% (ranging from 23.3% in 1996 to 41.7% in 1990), cocaine for 37.6% (ranging from 16.7% in 1990 to 50.0% in 1999) and alcohol/drug combination for 32.9% (ranging from 24.9% in 2001 to 47.1% in 1992).

Overall drug overdose death and types of drugs causing death

Table 1 shows counts and age-adjusted rates of unintentional drug overdose death from 1990 to 2005. The total unintentional overdose death rate increased from 5.6 per 100 000 ($n = 84$) in 1990 to 8.8 per 100 000 ($n = 153$) in 1997, and then increased to 15.5 per 100 000 ($n = 289$) in 2005. During 1990–2005, the proportion of drug overdose deaths caused by heroin, prescription opioids, cocaine or alcohol/drug combination was 93.0% ($n = 2620$) overall, ranging from 88.7% in 1992 to 98.5% in 1994. The peak year for death rates from heroin and alcohol/drug combination was 1998 and the peak for death rates from prescription opioids and cocaine was 2003. The largest rate increase over the study period was observed for cocaine overdose death, rising 612% from 0.8 per 100 000 in 1990 to 5.7 per 100 000 in 2005. Counts and rates in Table 1 represent the drugs causing death either alone or in combination with other drugs.

Single and multi-drug overdose death

As seen in Table 2, the overdose death rate from one drug category ranged from a low of 2.2 per 100 000 in 1991 to a peak of 8.0 deaths per 100 000 in 2005. The highest unintentional overdose death rates from one drug category were found for prescription opioids (1.8 per 100 000) and heroin (1.6 per 100 000) over all years, although the prescription opioid death rate was consistently higher than the heroin overdose death rate only during 2000–05. The overall death rate from one drug category increased 196% from 1990 to 2005.

Over all years, death caused by use of two or more substances (among the categories of heroin, prescription opioids, cocaine and alcohol/drug) was found for 47.2% ($n = 1330$; 4.9 deaths per 100 000) of all unintentional drug overdose. The overdose death rate from at least two drug categories peaked at 6.5 per 100 000 in 2003, and the most common combination of drug categories causing overdose death was heroin/alcohol, followed by heroin/cocaine. The heroin/alcohol overdose death rate was lowest in 1990 and peaked in 1998. The heroin/cocaine overdose death rate was also lowest in 1990 and peaked in 1999. The overall death rate from two or more drug categories increased 148% from 1990 to 2005.

Death rates from one and two or more drugs are also shown in Table 2. The single drug overdose death rate increased 158% over all years, rising from 2.6 per 100 000 in 1990 to 6.7 per 100 000 in 2005. Over all

Table 1 Unintentional drug overdose death numbers and rates for New Mexico decedents, 1990–2005.

	Total		*Heroin, prescription opioids, cocaine or alcohol/drug*		*Heroin**		*Prescription opioids**		*Cocaine**		*Alcohol/drug**	
	n	*Rate*	*n*	*Rate*	*n*	*Rate*	*n*	*Rate*	*n*	*Rate*	*n*	*Rate*
1990	84	5.6	79	5.2	38	2.6	35	2.2	14	0.8	32	2.1
1991	90	5.6	81	5.1	41	2.6	37	2.3	18	1.0	40	2.5
1992	104	6.7	93	5.9	53	3.4	34	2.2	34	2.1	49	3.2
1993	125	7.6	113	6.9	76	4.6	41	2.4	41	2.4	52	3.1
1994	121	7.3	119	7.2	68	4.1	38	2.3	47	2.7	45	2.7
1995	134	7.9	128	7.6	92	5.5	35	2.1	36	2.1	55	3.3
1996	146	8.5	137	7.9	81	4.7	34	2.0	49	2.8	55	3.2
1997	153	8.8	142	8.2	78	4.5	47	2.7	74	4.2	56	3.2
1998	214	12.2	205	11.7	133	7.6	64	3.6	78	4.5	78	4.5
1999	208	11.8	197	11.2	115	6.5	63	3.6	104	5.9	61	3.5
2000	205	11.5	194	10.9	117	6.6	63	3.5	91	5.1	73	4.1
2001	193	10.7	176	9.7	81	4.5	75	4.1	78	4.4	48	2.7
2002	233	12.9	221	12.3	120	6.7	68	3.8	94	5.3	75	4.2
2003	283	15.5	255	13.9	103	5.7	111	6.0	110	6.1	77	4.2
2004	236	12.5	215	11.4	89	4.8	102	5.4	88	4.7	59	3.2
2005	289	15.5	265	14.2	125	6.8	108	5.7	105	5.7	73	4.0
1990–2005	2818	10.4	2620	9.6	1410	5.2	955	3.5	1061	3.9	928	3.4
% change		177%		173%		161%		159%		612%		90%

*Not mutually exclusive, where the drug may have caused death either alone or in combination with other drug(s).

years, the multi-drug overdose death rate increased 188% and peaked at 7.5 deaths per 100 000 in 2005.

Overall drug overdose death among racial/ethnic groups and sex

Annual unintentional drug overdose death rates were calculated by race and sex. The overall overdose death rate increased 58% among Hispanics (11.3 per 100 000 in 1990 to 17.9 per 100 000 in 2005), 478% among whites (2.8 per 100 000 in 1990 to 16.2 per 100 000 in 2005) and 900% among American Indians (0.5 per 100 000 in 1990 to 5.0 per 100 000 in 2005). The overall overdose death rate increased 123% among males (10.2 per 100 000 in 1990 to 22.8 per 100 000 in 2005) and 664% among females (1.1 per 100 000 in 1990 to 8.4 per 100 000 in 2005).

Figure 1 shows trends in drug overdose death by race/sex classes from 1990 to 2005. During this time period, overdose death rates were highest among Hispanic males (24.8 per 100 000), followed by white males (11.8 per 100 000), white females (5.2 per 100 000), Hispanic females (4.9 per 100 000), American Indian males (4.4 per 100 000) and American Indian females (1.4 per 100 000). The death rate peaked at 31.4 per 100 000 among Hispanic males in 2003, 21.1 per 100 000 among white males in 2005 and 7.8 per 100 000 among American Indian males in 2002. The overdose death rate among white females was higher than the rate among Hispanic females for 10 of the 16 years studied and consistently higher than the rate among American Indian females over all years. In 2005, there were 11.4 deaths per 100 000 among white females, 7.1 deaths per 100 000 among Hispanic females and 2.8 deaths per 100 000 among American Indian females.

Types of drug overdose death among race/sex classes

We then examined drug overdose death by the major types of drugs causing death, either alone or in combination with other categories, among race/sex classes. Among Hispanic males, heroin-caused overdose death was most frequent over all years studied (16.0 deaths per 100 000) and peaked in 1998 at 22.2 deaths per 100 000. Heroin was also the most frequent drug causing overdose death among white males, peaking in 2000 at 8.7 deaths per 100 000. Since 2000, however, the heroin-caused overdose death rate among white males declined to match the death rates from prescription opioids and cocaine. During the time period studied, overdose death among American Indian males was caused most often by heroin and alcohol/drug combinations (both death rates were 2.2 per 100 000).

Among Hispanic females, overdose death from prescription opioids was most common over all years studied (2.3 deaths per 100 000), peaking at 4.6 per 100 000 in

Table 2 Unintentional drug overdose death rates for the most common drug category/combinations found causing death: heroin (Her), prescription opioids, cocaine (Coc) and alcohol, New Mexico 1990–2005.

	Drug categories: heroin, prescription opioids, cocaine, alcohol								*Number of drug categories*		*Number of drugs*	
	Opioids	*Her*	*Her + alcohol*	*Coc*	*Her + Coc*	*Her + Coc + alcohol*	*Opioids + alcohol*	*Opioids + Coc*	*1 category*	*2+ categories*	*1 drug*	*2+ drugs*
1990	0.8	1.3	0.6	0.4	0.2	0.1	1.0	0.1	2.7	2.5	2.6	2.6
1991	0.6	1.1	0.7	0.2	0.3	0.1	0.7	0.2	2.2	2.8	2.2	2.9
1992	0.7	0.7	1.3	0.6	0.3	0.5	0.4	0.1	2.4	3.5	2.3	3.7
1993	0.7	1.2	1.4	0.7	0.2	0.6	0.3	0.2	2.8	4.1	2.6	4.3
1994	0.9	1.2	0.9	0.8	0.6	0.5	0.4	0.1	3.4	3.7	3.1	4.1
1995	0.7	2.2	1.5	0.3	0.4	0.5	0.4	0.1	3.5	4.1	3.5	4.1
1996	0.9	2.1	1.2	0.8	0.3	0.6	0.3	0.2	4.3	3.6	4.0	3.9
1997	1.2	0.9	1.2	1.2	0.9	0.8	0.4	0.3	3.5	4.7	3.0	5.1
1998	2.1	2.3	2.0	0.7	1.4	1.1	0.4	0.3	5.4	6.3	4.9	6.7
1999	1.5	1.8	1.1	1.5	1.7	1.0	0.3	0.7	5.1	6.1	5.1	6.1
2000	1.7	1.4	1.8	1.0	1.4	1.2	0.2	0.7	4.5	6.4	4.1	6.7
2001	2.5	1.6	0.7	1.4	0.8	0.8	0.3	0.4	5.7	4.1	4.9	4.6
2002	2.4	2.0	1.5	1.5	1.5	1.1	0.4	0.2	6.3	6.0	5.7	6.5
2003	3.8	1.3	1.5	2.2	1.6	0.9	0.7	0.8	7.5	6.5	6.7	7.2
2004	3.1	1.4	0.7	1.3	1.4	0.7	0.9	0.7	6.0	5.4	5.5	5.9
2005	3.5	2.3	1.5	1.9	1.3	1.0	0.8	0.7	8.0	6.2	6.7	7.5
1990–2005	1.8	1.6	1.2	1.1	0.9	0.7	0.5	0.4	4.7	4.9	4.3	5.3
% change	337%	77%	150%	375%	550%	900%	–20%	600%	196%	148%	158%	188%

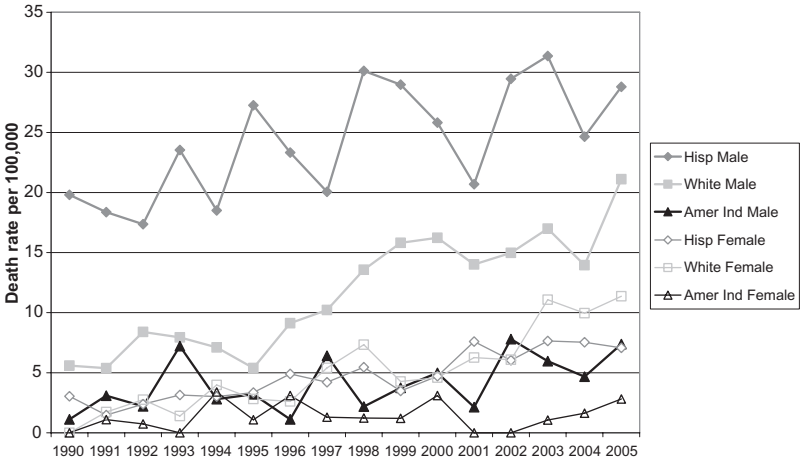

Figure 1 Unintentional drug overdose death rates by race and sex classes, New Mexico 1990–2005

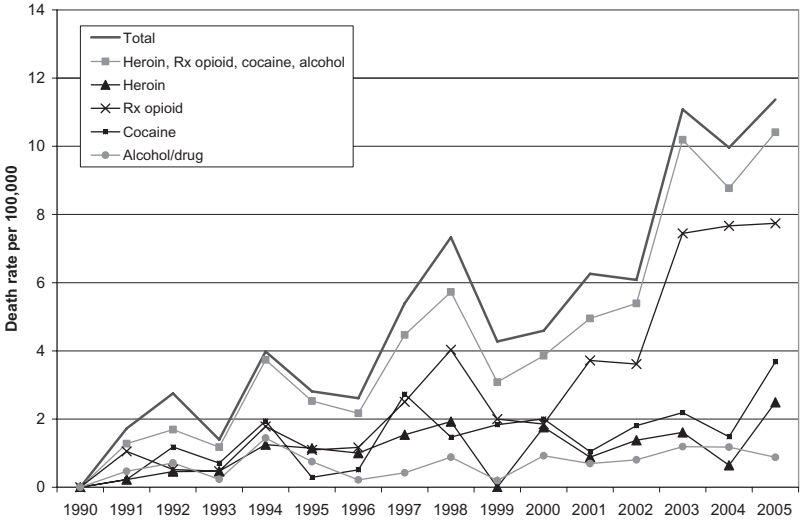

Figure 2 Unintentional drug overdose death rates and category of drug causing overdose death among white females, New Mexico 1990–2005

2001. The same was found for white females, although the death rate from prescription opioids rose dramatically during the last half of the study period. Since 2000, the prescription opioid death rate for white females increased by 325% from 1.8 deaths per 100 000 to a peak of 7.7 deaths per 100 000 in 2005. Figure 2 shows trends in unintentional drug overdose death rates among white females during the study period.

Drug combinations causing overdose death among race/sex classes

We calculated 2-year death rates for the unique drug category combinations found causing death among race/sex classes from 1990 to 2005; the most common categories are shown in Table 3. During the time period studied, Hispanic male overdose death was most often caused by heroin alone and heroin/alcohol, white male overdose death was caused most often by prescription opioids alone and heroin alone, and both Hispanic and white female overdose death was caused most often by prescription opioids alone. Among American Indians, the most common drug combination causing overdose death over all years studied was heroin/alcohol (0.9 per 100 000) among males and prescription opioids/alcohol (0.2 per 100 000) among females (data not shown).

Death rates from single and multi-drug categories by race/sex classes are also shown in Table 3. From 1990 to 2005, overdose death from one drug category increased 27% among Hispanic males, 224% among white males, 500% among Hispanic females and 1320% among white females. Overdose death from multiple drug categories increased by 58% among Hispanic males, 221% among white males, 40% among Hispanic females and 1150% among white females.

Prescription opioid overdose death

There was an 81% increase in the unintentional overdose death rate caused by prescription opioids, either alone or in combination with other drugs, during the last half of the study period. As 34% ($n = 955$) of all unintentional

Table 3 Rates of unintentional drug overdose death for the most common drug category/combinations found causing death by race/sex classes, New Mexico 1990–2005.

Race/sex class and drug combinations	*1990–91*	*1992–93*	*1994–95*	*1996–97*	*1998–99*	*2000–01*	*2002–03*	*2004–05*	*1990–2005*
Hispanic male									
Opioids	1.6	2.0	0.8	1.3	1.7	1.5	3.2	2.8	2.0
Her	4.7	3.7	5.8	4.6	5.9	3.4	5.5	4.0	4.7
Her + alcohol	3.2	5.3	5.6	4.3	5.3	4.6	4.7	3.8	4.7
Coc	0.8	1.2	1.3	2.2	2.7	3.0	4.2	3.2	2.5
Her + Coc	1.1	0.6	1.3	1.9	3.8	2.6	3.3	4.0	2.4
Her + Coc + alcohol	0.3	1.7	1.8	2.1	3.9	2.6	3.2	2.6	2.4
Opioids + alcohol	2.5	0.7	1.0	1.3	0.6	0.3	0.9	1.9	1.1
Opioids + Coc	0.4	0.5	0.0	0.3	1.2	0.9	0.8	1.1	0.7
1 drug category	8.1	7.8	8.7	8.5	10.6	8.7	13.3	10.3	9.7
2+ drug categories	9.6	12.0	13.8	12.3	18.5	14.1	16.1	15.2	14.3
White male									
Opioids	0.9	1.0	0.9	1.3	2.9	4.0	4.1	4.2	2.4
Her	1.3	0.7	1.7	1.3	3.1	2.8	0.8	2.4	1.8
Her + alcohol	0.5	1.2	0.4	1.1	2.0	0.9	1.5	0.9	1.1
Coc	0.5	0.7	0.7	1.3	1.1	1.3	2.0	2.1	1.2
Her + Coc	0.1	0.3	0.3	0.6	2.0	1.3	1.7	1.3	0.9
Her + Coc + alcohol	0.0	0.6	0.5	0.8	0.4	1.3	0.6	1.1	0.7
Opioids + alcohol	0.5	0.6	0.4	0.2	0.7	0.1	1.2	1.1	0.6
Opioids + Coc	0.1	0.1	0.0	0.1	0.6	0.4	0.6	0.6	0.3
1 drug category	2.9	3.0	3.8	4.2	7.3	8.5	7.4	9.4	5.9
2+ drug categories	1.9	4.1	2.3	4.3	7.0	5.0	6.6	6.1	4.7
Hispanic female									
Opioids	0.4	0.2	0.3	1.1	1.0	2.0	1.9	2.6	1.3
Her	0.0	0.4	0.7	1.1	0.6	0.7	0.6	1.4	0.7
Her + alcohol	0.0	0.2	0.1	0.4	0.1	0.3	0.1	0.3	0.2
Coc	0.0	0.5	0.1	0.3	0.4	0.6	0.9	0.8	0.5
Her + Coc	0.0	0.1	0.4	0.2	1.1	0.4	1.3	0.4	0.5
Her + Coc + alcohol	0.0	0.1	0.3	0.3	0.4	0.3	0.1	0.2	0.2
Opioids + alcohol	1.0	0.3	0.4	0.3	0.0	0.3	0.0	0.3	0.3
Opioids + Coc	0.0	0.0	0.1	0.2	0.1	0.6	0.5	0.3	0.2
1 drug category	0.8	1.1	1.2	2.8	2.0	3.6	3.5	4.8	2.6
2+ drug categories	1.5	1.5	1.9	1.8	2.4	2.3	2.6	2.1	2.1
White female									
Opioids	0.3	0.3	1.0	1.0	1.9	2.0	4.5	5.8	2.1
Her	0.1	0.1	0.6	0.5	0.5	0.1	0.7	0.6	0.4
Her + alcohol	0.0	0.1	0.1	0.1	0.0	0.4	0.1	0.0	0.1
Coc	0.0	0.4	0.1	0.5	0.7	0.4	0.9	0.7	0.5
Her + Coc	0.0	0.1	0.4	0.4	0.1	0.6	0.4	0.4	0.3
Her + Coc + alcohol	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.0	0.1
Opioids + alcohol	0.1	0.0	0.4	0.1	0.3	0.3	0.5	0.5	0.3
Opioids + Coc	0.1	0.1	0.0	0.5	0.5	0.4	0.2	0.8	0.3
1 drug category	0.5	0.7	1.8	2.1	3.2	2.5	6.1	7.1	3.1
2+ drug categories	0.2	0.7	1.5	1.4	1.3	1.9	1.7	2.5	1.4

Coc: cocaine; Her: heroin.

drug overdose deaths were caused by prescription opioids, 49% ($n = 470$) of those deaths were caused in combination with heroin, cocaine or alcohol. Figure 3 shows the cumulative contribution of each drug combination to the sum of all overdoses caused by prescription opioids between 1990 and 2005. Over all years, the proportion of total prescription opioid overdose deaths grew from 36% in 1990 (0.8 deaths per 100 000 of 2.2 per 100 000) to 61% in 2005 (3.5 deaths per 100 000 of 5.7 per 100 000). In addition, the overall overdose death rate from prescription opioids alone was highest among white males (2.4 per 100 000) and white females (2.1 per 100 000). The overdose death rate from prescription opioids in combination with other drug categories was

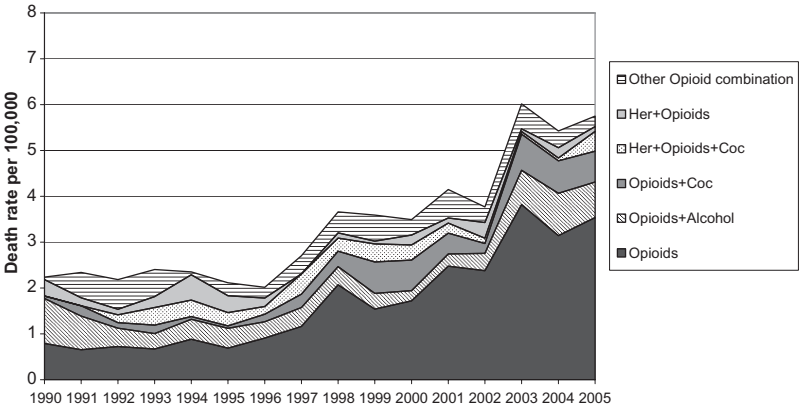

Figure 3 The cumulative contribution of drug combinations to the sum of unintentional prescription opioid overdose deaths, New Mexico 1990–2005

highest among Hispanic males (4.1 per 100 000) and white males (1.8 per 100 000) over all years.

Modeling overall overdose death

There was further evidence from the regression model that unintentional drug overdose death differed by sex and race/ethnicity, after adjusting for age group and New Mexico region. The risk of overdose was significantly higher for males compared to females (RR = 3.37; 95% CI: 3.08, 3.68). Compared to whites, the risk of overdose was significantly higher among Hispanics for almost every year during the study period, with RR ranging from 1.30 to 3.66, except in 2005 (RR = 1.06; 95% CI: 0.84, 1.34). The interaction between Hispanic race and year shows that the increased risk of overdose death among Hispanics compared to whites diminished significantly over time. American Indians were significantly less likely than whites to die from drug overdose over all years (RR = 0.36; 95% CI: 0.28, 0.47). Among males, the same relationship was observed where risk of overdose death was significantly higher among Hispanic males relative to white males (RR ranging from 1.52 to 4.92), except in 2005 (RR = 1.29; 95% CI: 0.98, 1.71), but there was no significant difference in risk of overdose death between Hispanic females and white females. The same significantly reduced overdose risk was found among American Indian males compared to white males (RR = 0.41; 95% CI: 0.31, 0.55) and American Indian females compared to white females (RR = 0.27; 95% CI: 0.17, 0.43).

DISCUSSION

There has been a substantial increase in unintentional drug overdose death in New Mexico since 1990. The proportion of total unintentional overdose death caused by heroin, prescription opioids, cocaine and alcohol/drug combinations together ranged from 89% to 98% during 1990–2005. Although heroin alone or in combination with other drugs caused the most overdose deaths during the study period, there was a notable increase in the overdose death rate attributed to prescription opioids during 1998–2005. Over all years, Hispanic males had the highest drug overdose death rate, followed by white males, white females, Hispanic females and American Indians. The most common drug combinations causing overdose death were heroin alone and heroin/alcohol among Hispanic males, heroin/alcohol among American Indian males and prescription opioids alone among white males and all female subpopulations.

From 1990 to 2005, the overdose death rate caused by use of only one drug (among heroin, prescription opioids, cocaine) or by an alcohol/drug combination increased nearly 200%, driven by increases in death caused by prescription opioids and heroin. Overdose death from at least two of the categories increased roughly 150%, driven by increases in death caused by heroin/alcohol and heroin/cocaine combinations. During the last half of the study period, the multi-drug category overdose death rate remained relatively stable, while the death rate from one drug category increased 48% and surpassed the death rate from multiple categories in 2001. The greatest rate increases for both single and multi-drug category overdose death were found for females. In addition, the overdose death rate from only one drug (as opposed to one drug category) increased roughly 160% over all years and peaked in 2005, nearly matching the overdose death rate from multiple drugs. The authors are not aware of other locales reporting this overall trend, and previous research in the United States and abroad has suggested that changes in drug overdose death over time were due to changing trends in multi-drug overdose death [14–16]. Public health efforts aimed at reducing multi-drug use may be influential in decreasing overall unintentional overdose death, but the subgroups most at risk for single drug overdose death deserve equal attention in New Mexico. It would be interesting to determine whether this recent rise in single drug overdose

death has been observed elsewhere and evaluate potential reasons for the changing trend.

Prescription opioids caused 34% of unintentional drug overdose deaths in New Mexico during 1990–2005, emerging as a leading cause of overdose death. We found that prescription opioids caused overdose death more often among females than any other drug type during the study period, and contributed largely to the fivefold increase in the overall drug overdose death rate among females. Among white females, in particular, there was an alarming increase in the overdose death rate from prescription opioids from 2000 to 2005. In New Mexico during 1993–2004, an increasing trend in prescription opioid overdose death was documented [28], especially in rural areas [27], adding to the already severe burden from illicit drug use in the state. The further characterization of opioid overdose decedents and the finding of such high rates of death among females justify a concerted effort for overdose prevention and education among women who use these drugs.

The most frequent drug category causing overdose death since 2001 was prescription opioids alone, exceeding death from heroin alone and heroin/alcohol. There has been an increasing trend world-wide in the use of prescription opioids for both medical [30–35] and non-medical purposes [36,37]. Unfortunately, this study cannot address the circumstances of use or drug source (i.e. physician prescription, friend/family, street diversion, internet, Mexican pharmacies). We cannot overemphasize the need to clarify the extent of prescription opioid diversion and abuse. However, it is possible that a sizeable proportion of decedents from opioids alone were accessing services and had a medical encounter during which time opioid use was verified by a health-care professional, an opportune window to engage and educate the patient and family members on safe drug use. The role of providers may be decisive in reducing drug overdose. Overall community health would benefit if primary care providers in areas of high drug use prevalence were equipped with advanced training in addiction medicine [38,39] and demonstrated knowledge concerning opioid prescribing guidelines (i.e. tolerance, dose escalation) [40] and the effective practice for treating pain, particularly the opposing dilemmas of potential diversion/abuse of opioids and undertreatment of pain [41].

Because heroin continues to cause the most unintentional overdose deaths in New Mexico, it is essential that harm reduction programs continue the delivery of consistent overdose prevention campaigns with expansion and diffusion of current strategies. Efforts should be supported to train more physicians and counselors in using buprenorphine; as of June 2007, 60 physicians and six treatment centers in New Mexico were certified. Policy development such as non-prescription naloxone availability and training for people (and family and friends) who use prescription opioids, not only heroin users, may also reduce the number of unintentional overdose deaths caused by opiates [39].

Hispanics were over-represented among unintentional drug overdose deaths compared to the general population, comprising 55% of decedents and roughly 40% of the New Mexico population. Rates of overdose death among Hispanics were consistently higher than whites during the study period. Although the death rate for both Hispanics and whites increased since 1990, the disparity was diminishing in recent years. Research in New York City has also shown higher overdose death rates among Hispanics compared to whites [16,42]. Recent national estimates for current illicit drug use among people aged 12 years and older were 8.1% of whites and 7.6% of Hispanics [11]. Given the similar drug use prevalence by race/ethnicity, it is important to understand the issues that impact disparity in overdose death between Hispanics and whites in the United States. These may range from direct factors that affect overdose death, such as drug use patterns and attitudes about activating emergency services [42], to underlying health-related factors that may be associated indirectly with the outcome of overdose death, such as differential levels of unmet treatment need [43], insurance status [44,45], language barrier [46] and poverty [47,48]. In addition, it is important to identify factors among heterogeneous Hispanic subgroups in New Mexico that may result in worse drug use outcomes, such as increased levels of acculturation [49,50] and heritage [51]. Lastly, pharmacogenetic research could help to explain racial differences in drug overdose death outcome and drug use patterns. These data show that heroin and psychostimulant addiction is highly heritable and drug-specific gene susceptibility varies by race/ethnicity [52]. This research direction may also elucidate gene variants among subpopulations that predict drug vulnerability and response to medication-assisted treatment. These are significant steps towards the goal of individualizing clinical treatment and informing effective prevention strategies.

There were limitations to the present study. We analyzed unintentional drug overdose when it was designated as the cause of death by OMI. Variability among medical examiners is possible, leading to misclassification of the drug causing death and single versus multi-drug overdose among some decedents analyzed in this study. Secondly, the study findings may not be generalizable to the same racial/ethnic groups elsewhere. Finally, unintentional overdose death rates among American Indians were lowest compared to Hispanics and whites, but it is unknown how many overdose deaths occurred on tribal land as OMI is not always contracted to investigate these deaths. In New Mexico, there is a formal agreement with

American Indian tribes to ensure that death certificates for tribal members are included in the state death records. Therefore, we compared American Indian unintentional overdose death from OMI data to the same from state death records to clarify the extent to which OMI was contracted by tribes to investigate overdose death during 1999–2005. There was a difference of four decedents (< 10% of total decedents), suggesting that OMI was contracted to investigate most deaths on tribal land that were identified as unintentional drug overdose on the death certificate. Furthermore, analysis of national death data from 1990 to 2003 showed that unintentional overdose death rates among American Indians in the United States were, on average, 30% higher than death rates for American Indians in New Mexico over all years (3.2 per 100 000 in the United States versus 2.5 per 100 000 in New Mexico), yet the rate of increase was similar (234% for the United States and 214% for New Mexico) [53].

In conclusion, there is great benefit in identifying subpopulations most at risk for overdose within a particular locale and tracking these subpopulations over time. In the United States and abroad, region-specific surveillance is necessary as these target populations vary by region and subregion. Prevention programs and interventions to reduce overdose death should be tailored according to trends in the use of drug combinations among at-risk subpopulations. It is evident that reducing drug overdose death warrants a more comprehensive public health approach with attention to both illicit and prescription drug users, as well as the overlap of concurrent users.

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References

1. Goldstein A., Herrera J. Heroin addicts and methadone treatment in Albuquerque: a 22-year follow-up. *Drug Alcohol Depend* 1995; **40**: 139–50.
2. US Department of Health and Human Services, Centers for Disease Control and Prevention. Unintentional and undetermined poisoning deaths—11 states, 1990–2001. *MMWR* 2004; **53**: 233–8.
3. US Department of Health and Human Services, Centers for Disease Control and Prevention. CDC wonder. Available at: http://wonder.cdc.gov/ (accessed 24 January 2007).
4. Joe G. W., Simpson D. D. Mortality rates among opioid addicts in a longitudinal study. *Am J Public Health* 1987; **77**: 347–8.
5. Oppenheimer E., Tobutt C., Taylor C., Andrew T. Death and survival in a cohort of heroin addicts from London clinics: a 22 year follow-up. *Addiction* 1994; **89**: 1299–308.
6. Orti R. M., Domingo-Salvany A., Munoz A., Macfarlane D., Suelves J. M., Anto J. M. Mortality trends in a cohort of opiate addicts, Catalonia, Spain. *Int J Epidemiol* 1996; **25**: 545–53.
7. Hulse G. K., English D. R., Milne E., Holman C. D. J. The quantification of mortality resulting from the regular use of illicit opiates. *Addiction* 1999; **94**: 221–9.
8. Hser Y.-I., Hoffman V., Grella C. E., Anglin M. D. A 33-year follow-up of narcotics addicts. *Arch Gen Psychiatry* 2001; **58**: 503–8.
9. Preti A., Miotto P., De Coppi M. Deaths by unintentional illicit drug overdose in Italy, 1984–2000. *Drug Alcohol Depend* 2002; **66**: 275–82.
10. Gossop M., Stewart D., Treacy S., Marsden J. A prospective study of mortality among drug misusers during a 4-year period after seeking treatment. *Addiction* 2002; **97**: 39–47.
11. Office of Applied Studies. *Results from the 2005 National Survey on Drug Use and Health: National Findings.* DHHS Publication no. SMA 06-4194, NSDUH Series H-30. Rockville, MD: Substance Abuse and Mental Health Services Administration. Available at: http://www.oas.samhsa.gov/p0000016.htm#2k5 (accessed 24 January 2007).
12. US Department of Health and Human Services, Centers for Disease Control and Prevention. Unintentional poisoning deaths—United States, 1999–2004. *MMWR* 2007; **56**: 93–6.
13. Darke S., Zador D. Fatal heroin 'overdose': a review. *Addiction* 1996; **91**: 1765–72.
14. Risser D., Uhl A., Stichenwirth M., Honigschnabl S., Hirz W., Schneider B. *et al.* Quality of heroin and heroin-related deaths from 1987 to 1995 in Vienna, Austria. *Addiction* 1987; **95**: 375–82.
15. Darke S., Ross J., Zador D., Sunjic S. Heroin-related deaths in New South Wales, Australia, 1992–1996. *Drug Alcohol Depend* 2000; **60**: 141–50.
16. Coffin P. O., Galea S., Ahern J., Leon A., Vlahov D., Tardiff K. Opiates, cocaine and alcohol combinations in accidental drug overdose deaths in New York City, 1990–1998. *Addiction* 2003; **98**: 739–47.
17. Sporer K. A. Acute heroin overdose. *Ann Intern Med* 1999; **130**: 584–90.
18. Darke S., Hall W. Heroin overdose: research and evidence-based interventions. *J Urban Health* 2003; **80**: 189–200.
19. White J. M., Irvine R. J. Mechanisms of fatal opioid overdose. *Addiction* 1999; **94**: 961–72.
20. Fugelstad A., Ahlner J., Brandt L., Ceder G., Eksborg S., Rajs J. *et al.* Use of morphine and 6-monoacetylmorphine in blood for the evaluation of possible risk factors for sudden death in 192 heroin users. *Addiction* 2003; **98**: 463–70.
21. Thiblin I., Eksborg S., Petersson A., Fugelstad A., Rajs J. Fatal intoxication as a consequence of intranasal administration (snorting) or pulmonary inhalation (smoking) of heroin. *Forensic Sci Int* 2004; **139**: 241–7.
22. Dietze P., Jolley D., Fry C., Bammer G. Transient changes in behaviour lead to heroin overdose: results from a case-crossover study of non-fatal overdose. *Addiction* 2005; **100**: 873–4.
23. Davidson P. J., McLean R. L., Kral A. H., Gleghorn A. A., Edlin B. R., Moss A. R. Fatal heroin-related overdose in San Francisco, 1997–2000: a case for targeted intervention. *J Urban Health* 2003; **80**: 261–73.
24. Tobin K. E., Davey M. A., Latkin C. A. Calling emergency medical services during drug overdose: an examination of individual, social and setting correlates. *Addiction* 2005; **100**: 397–404.
25. Hembree C., Galea S., Ahern J., Tracy M., Markham Piper

T., Miller J. *et al.* The urban built environment and overdose mortality in New York City neighborhoods. *Health Place* 2005; **11**: 147–56.
26. Darke S., Hall W., Weatherburn D., Lind B. Fluctuations in heroin purity and the incidence of fatal heroin overdose. *Drug Alcohol Depend* 1999; **54**: 155–61.
27. US Department of Health and Human Services, Centers for Disease Control and Prevention. Unintentional deaths from drug poisoning by urbanization of area—New Mexico, 1994–2003. *MMWR* 2005; **54**: 870–3.
28. Mueller M. R., Shah N. G., Landen M. G. Unintentional prescription drug overdose deaths in New Mexico, 1994–2003. *Am J Prev Med* 2006; **30**: 423–9.
29. US Bureau of the Census, Population Estimates Program. Bridged-race intercensal population estimates for July 1, 1990–July 1, 1999, by year, county, single-year of age, Hispanic origin, and sex (New Mexico). Available at: http://www.cdc.gov/nchs/about/major/dvs/popbridge/datadoc.htm#inter1 (accessed 24 January 2007).
30. World Health Organization. *Cancer Pain Relief: With a Guide to Opioid Availability.* Geneva: World Health Organization; 1996.
31. Bell J. R. Australian trends in opioid prescribing for chronic non-cancer pain, 1986–1996. *Med J Aust* 1997; **167**: 126–9.
32. Joranson D. E., Ryan K. M., Gilson A. M., Dahl J. L. Trends in medical use and abuse of opioid analgesics. *JAMA* 2000; **283**: 1710–14.
33. Novak S., Nemeth W. C., Lawson K. A. Trends in medical use and abuse of sustained-release opioid analgesics: a revisit. *Pain Med* 2004; **5**: 59–65.
34. Gilson A. M., Ryan K. M., Joranson D. E., Dahl J. L. A reassessment of trends in the medical use and abuse of opioid analgesics and the implications for diversion control: 1997–2002. *J Pain Symptom Manage* 2004; **28**: 176–88.
35. Zerzan J. T., Morden N. E., Soumerai S., Ross-Degnan D., Roughead E., Zhang F. *et al.* Trends and geographic variation of opiate medication use in state Medicaid fee-for-service programs, 1996–2002. *Med Care* 2006; **40**: 1005–10.
36. Manchikati L. Prescription drug abuse: what is being done to address this new drug epidemic? Testimony before the Subcommittee on Criminal Justice, Drug Policy and Human Resources. *Pain Physician* 2006; **9**: 287–321.
37. Compton W. M., Volkow N. D. Abuse of prescription drugs and the risk of addiction. *Drug Alcohol Depend* 2006; **83**: S4–S7.
38. Ritson E. B. Alcohol, drugs and stigma. *Int J Clin Pract* 1999; **53**: 549–51.
39. Beletsky L., Ruthazer R., Macalino G. E., Rich J. D., Tan L., Burris S. Physicians' knowledge of and willingness to prescribe naloxone to reverse accidental opiate overdose: challenges and opportunities. *J Urban Health* 2007; **84**: 126–36.
40. Franklin G. M., Mai J., Wickizer T., Turner J. A., Fulton-Kehoe D., Grant L. Opioid dosing trends and mortality in Washington State workers' compensation, 1996–2002. *Am J Ind Med* 2005; **48**: 91–9.
41. Zacny J., Bigelow G., Compton P., Foley K., Iguchi M., Sannerud C. College on Problems of Drug Dependence taskforce on prescription opioid nonmedical use and abuse: position statement. *Drug Alcohol Depend* 2003; **69**: 215–32.
42. Galea S., Ahern J., Tardiff K., Leon A., Coffin P. O., Derr K. *et al.* Racial/ethnic disparities in overdose mortality trends in New York City, 1990–1998. *J Urban Health* 2003; **80**: 201–11.
43. Wells K., Klap R., Koike A., Sherbourne C. Ethnic disparities in unmet need for alcoholism, drug abuse, and mental health care. *Am J Psychiatry* 2001; **158**: 2027–32.
44. Hargraves J. L., Hadley J. The contribution of insurance coverage and community resources to reducing racial/ethnic disparities in access to care. *Health Serv Res* 2003; **38**: 809–29.
45. Kirby J. B., Taliaferro G., Zuvekas S. H. Explaining racial and ethnic disparities in health care. *Med Care* 2006; **44**: I64–I72.
46. Fiscella K., Franks P., Doescher M. P., Saver B. G. Disparities in health care by race, ethnicity, and language among the insured: findings from a national sample. *Med Care* 2002; **40**: 52–9.
47. Alegria M., Canino G., Rios R., Vera M., Calderon J., Rusch D. *et al.* Inequalities in use of specialty mental health services among Latinos, African Americans, and non-Latino whites. *Psychiatr Serv* 2002; **53**: 1547–55.
48. Shi L., Stevens G. D. Vulnerability and unmet health care needs. The influence of multiple risk factors. *J Gen Intern Med* 2005; **20**: 148–54.
49. Freeman R. C., Williams M. L., Saunders L. A. Drug use, AIDS knowledge, and HIV risk behaviors of Cuban-, Mexican-, and Puerto-Rican-born drug injectors who are recent entrants into the United States. *Subst Use Misuse* 1999; **34**: 1765–93.
50. Cherpitel C. J., Borges G. Substance use among emergency room patients: an exploratory analysis by ethnicity and acculturation. *Am J Drug Alcohol Abuse* 2002; **28**: 287–305.
51. US Department of Health and Human Services, National Institute on Drug Abuse. *Drug Abuse Among Racial/Ethnic Minorities.* Rockville, MD: National Institutes of Health, Publication no. 03-3888, 2003.
52. Rutter J. L. Symbiotic relationship of pharmacogenetics and drugs of abuse. *AAPS J* 2006; **8**: E174–E184.
53. US Department of Health and Human Services, National Center for Health Statistics. National Bureau of Economic Research: multiple cause-of-death mortality data. Available at: http://www.nber.org/data/multicause.html (accessed 24 January 2007).

