The effect of a reduction in heroin supply on fatal and non-fatal drug overdoses in New South Wales, Australia

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ABSTRACT

Objective: To examine the impact of a sudden and dramatic decrease in heroin availability, concomitant with increases in price and decreases in purity, on fatal and non-fatal drug overdoses in New South Wales, Australia.

Design and setting: Time-series analysis was conducted where possible on data on overdoses collected from NSW hospital emergency departments, the NSW Ambulance Service, and all suspected drug-related deaths referred to the NSW Coroner's court.

Main outcome measures: The number of suspected drug-related deaths where heroin and other drugs were mentioned; ambulance calls to suspected opioid overdoses; and emergency department admissions for overdoses on heroin and other drugs.

Results: Both fatal and non-fatal heroin overdoses decreased significantly after heroin supply reduced; the reductions were greater among younger age groups than older age groups. There were no clear increases in non-fatal overdoses with cocaine, methamphetamines or benzodiazepines recorded at hospital emergency departments after the reduction in heroin supply. Data on drug-related deaths suggested that heroin use was the predominant driver of drug-related deaths in NSW, and that when heroin supply was reduced overdose deaths were more likely to involve a wider combination of drugs.

Conclusion: A reduction in heroin supply reduced heroin-related deaths, and did not result in a concomitant increase, to the same degree, in deaths relating to other drugs. Younger people were more affected by the reduction in supply.

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The harm that heroin use causes its users and the community is disproportionate to the relatively low prevalence of its use in most developed countries.[1] One of the most common harms is heroin overdose, both fatal and non-fatal.[2] Research has suggested that many heroin-related deaths are polydrug deaths,[3] and it may be that the combinations of drugs involved in drug-related deaths change over time.[4]

During the 1990s, there was a substantial increase in the scale of Australian heroin markets. In New South Wales during 1993–1999, the price per gram of heroin reached a historic low, the purity of street heroin was 60%, and heroin was the most commonly injected drug among regular injecting drug users (IDUs).[5] In the late 1990s, there were substantial rises in the number of people being treated for heroin dependence, in deaths related to heroin overdose, arrests related to heroin, and in hepatitis C infections.[6-8]

Heroin overdose deaths became an issue of great public concern around the country in 1997.[9] In response, new harm-reduction initiatives were implemented in the late 1990s. In NSW, information about reducing the risk of overdose was distributed, NSW police made it standard policy *not* to accompany ambulance officers when they attended drug overdoses to reduce the fear of police apprehension among illicit drug users, and there were increases in the provision of opioid replacement therapies. Despite these efforts to reduce harm and demand, overdoses continued to increase.

In early 2001, a dramatic decline in the availability of heroin in Sydney was reported by injecting drug users, law enforcement personnel working in key drug markets across the city, and by those working in treatment agencies targeting heroin users.[10,11] These initial reports were confirmed across the country by the 2001 Illicit Drug Reporting System (IDRS), Australia's strategic early warning system,[12] and examined in the United Nations report *Global illicit drug trends*.[13] In NSW, the purity of heroin available on the street fell from 60% to around 25%–30%, availability decreased significantly, and the price of a "cap" of heroin doubled from $25 to $50.[14] The reduction in availability was most severe from January to April 2001, but the heroin supply still does not appear to have returned to the levels seen in the late 1990s, with the maintenance of lower purity levels and higher prices.[14] Following the onset of the shortage, regular IDUs reported less frequent heroin use, and increases in cocaine, methamphetamine and possibly benzodiazepine use were reported.[15,16]

Our aims were therefore to examine whether, after the reduction in heroin supply in Australia in 2000–2001, there was any change in:

- the number of non-fatal and fatal heroin overdoses;
- the number of cocaine, methamphetamine and benzodiazepine overdoses; and
- the drug combinations involved in deaths among "suspected drug takers" referred to the NSW Coroner for investigation.

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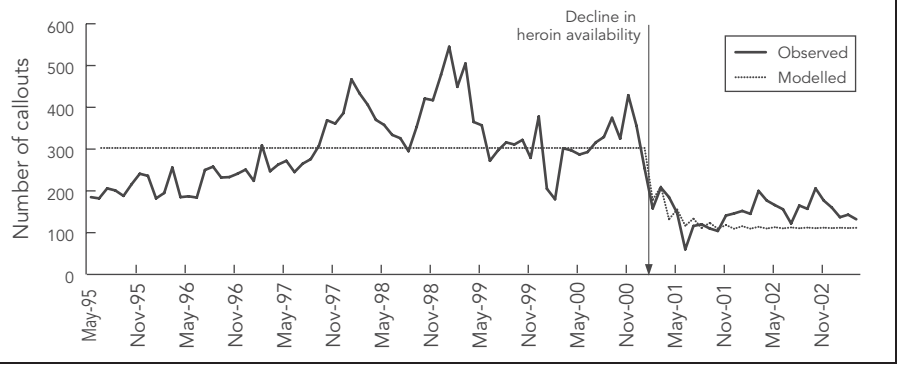
METHODS

This project was approved by the University of New South Wales Human Research Ethics Committee (HREC), the South East Sydney Area Health Service HREC, the South West Sydney Area Health Service HREC, the Central Sydney Area Health Service HREC and the Aboriginal Health and Medical Research Council Ethics Committee.

NSW Ambulance Service data

Data on the number of monthly callouts by the NSW Ambulance Service to suspected

1 Ambulance callouts to suspected heroin overdoses, 1995–2003



heroin overdoses were collected from 1 January 1995 to 30 June 2003. These data are based on cases in which the Ambulance Service protocol for drug overdose/poisoning was used and naloxone administered. This protocol includes overdoses of all drugs, and naloxone may be administered to unconscious patients who have not responded to other treatment.

Emergency department data

Data from emergency departments in NSW are collected centrally in NSW Health's Emergency Department Information System (EDIS), and data were obtained from NSW Health on overdoses between 1 January 1997 and 30 June 2003. Diagnostic information on people presenting to the emergency departments (ED) of NSW hospitals is coded using the *International classification of diseases, 9th revision* (ICD-9).[17] This information is recorded at the time of presentation to the ED. The following ICD-9 code groups were used to examine overdose of different drug types: (i) heroin — 965, 965.01, E850.0; (ii) methamphetamine — 969.7, E854.2; (iii) cocaine — 968.5; (iv) benzodiazepines — 969.4.

Data on suspected drug-related deaths

All cases of suspected drug-related deaths are referred to the NSW Coroner's court, and the NSW Division of Analytical Laboratories (DAL) performs pathology tests for all cases in which postmortem examinations are conducted, which includes all suspected drug-related deaths. Place of death, age and sex of the deceased are recorded. We included DAL data for all cases in which the deceased was identified by either police or pathologists as an illicit drug user or "known drug taker" between 1 January 1995 and 30 June 2003. For our analyses, cases in which a drug was detected at death were defined as deaths related to that drug. Previous analyses have suggested that there is good agreement between the number of such cases where heroin/morphine is detected, and the number of opioid-induced deaths as coded by the ABS in its Causes of Death database.

Drugs examined were heroin/morphine, methamphetamine, alcohol, cocaine, benzodiazepines, antidepressants, methadone, and other opioids (eg, fentanyl, pethidine, oxycodone).

The following drug combinations were examined: heroin only; heroin and benzodiazepines only; heroin and cocaine or methamphetamine only; heroin and alcohol only; heroin, benzodiazepines and alcohol only; heroin and central nervous system depressants not elsewhere classified; methadone alone, or methadone with benzodiazepines; heroin with other drug combinations; and other drug combinations without heroin (excluding all the above categories).

Statistical analysis

The data were analysed using an ARIMA (autoregressive integrated moving-average)-model time series with intervention terms.[18] Analyses showed that the intervention-model time series was not appropriate for some series. Natural spline smoothers with serially dependent residuals were fitted to these series to test the impact of the heroin shortage as a step or a pulse term. The intervention terms were linear and could be interpreted as for a standard linear model. Several models were tested with different numbers and types of basis points, and standard methods of model selection (generalised cross-validation, significance of terms, and low prediction variance) were used to select the best-fitting model. Model fitting for these types of smoothers is described elsewhere.[19] Linear models were fitted using S-Plus 6.1.[20]

RESULTS

Non-fatal overdose

The number of non-fatal heroin overdoses decreased substantially, whether measured by ambulance callouts or ED admissions. Box 1 shows the observed and modelled number of ambulance callouts to suspected heroin overdoses between 1995 and 2003. After adjusting for serial dependence, there was a 40% decrease ($P = 0.009$) after the reduction in heroin supply, which decayed over time to a final stable mean of 111.6 callouts per month (from an initial mean of 302.7 callouts per month). This represented an overall decrease of 63% ($P = 0.02$). There was a similar statistically significant 40% decline in the number of ED presentations for heroin overdose (Box 2).

In contrast to the strong effect observed for heroin overdoses, there was no significant change in methamphetamine or benzodiazepine overdose associated with the reduction in heroin supply (Box 2). This did not differ between sex or age groups.

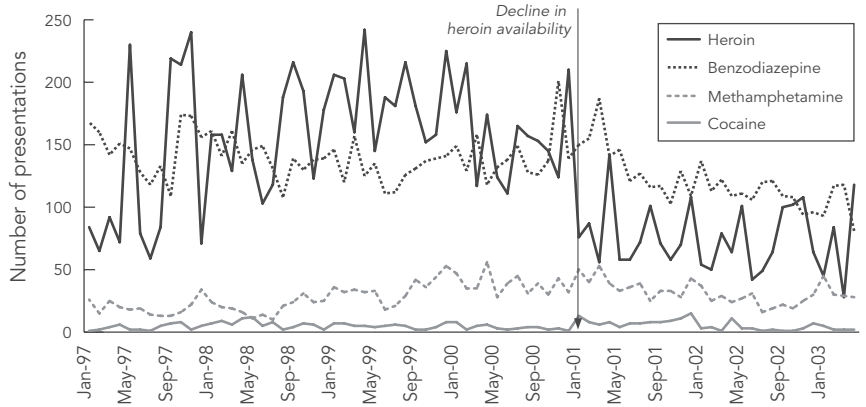
There was an apparent increase in cocaine overdose presentations to EDs across NSW at the time of the shortage (Box 2). This increase applied to both males and females, and to all age groups, except the older age group of 45 years and over. However, because of the very small numbers, statistical analyses were not possible.

Fatal overdose

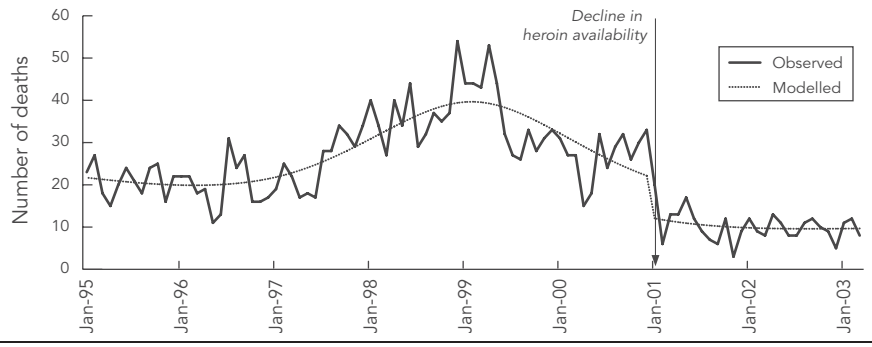
Data on suspected drug-related deaths between January 1995 and June 2003 showed a 43% decrease ($P < 0.0001$) in the number of drug-related deaths after the reduction in the supply of heroin (see Box 3).

Most of the steep drop was the result of a change in the number of deaths where heroin was involved (Box 4). After the reduction in heroin supply, there was a decrease in the number of deaths in which heroin was detected, and a corresponding decrease in the total number of deaths among suspected drug takers in NSW. Deaths involving alcohol and benzodiazepines decreased along with the shifts in the number of heroin-related deaths (Box 4). In contrast, deaths involving cocaine, methadone, methamphetamine and antidepressants remained stable.

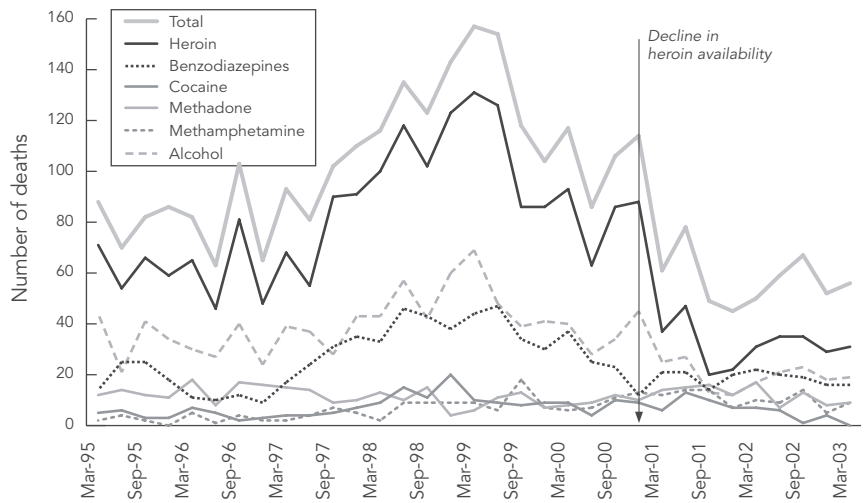
2 Drug overdose presentations to New South Wales emergency departments, 1997–2003



3 Number of suspected drug-related deaths, New South Wales, 1995–2003



4 Number of suspected drug-related deaths where particular drugs were detected *post mortem*, 1995–2003



The decline in deaths was similar for males and females. Among males, the number of deaths decreased from around 25 per month immediately before the heroin shortage to around 10 per month after the onset of the shortage. Among females, the number of deaths decreased from around five to seven per month to around two per month. These lower levels appear to have been maintained since then.

There were marked age differences in the trends in deaths where heroin was detected. There was a 65% decrease in heroin-related deaths among those aged 15–24 years ($P < 0.0001$), a 39% decrease in those aged 25–34 years ($P = 0.01$) and a 42% decrease in those aged 35–44 years ($P = 0.008$). A test of a model that included an interaction term between age and the decline in deaths (details available from the authors) indicated that there was no significant decrease in heroin-related deaths among people aged over 45.

Analyses of drug combinations detected among DAL cases (results not shown) showed that the proportion of all such deaths in which heroin was detected decreased from about 90% to 70%–75% after the onset of the heroin shortage. The proportion of deaths in which *only* heroin was detected decreased from around 25% to 10%. In contrast, the proportion of drug-related deaths where heroin was detected along with a range of other depressant drugs (methadone, alcohol, benzodiazepines, or other opioids) increased from around 10% of cases in December 2000 to 25% in December 2001. This was consistent with reports from injecting drug users suggesting increased polydrug use after the reduction in heroin supply.

DISCUSSION

In early 2001 there was a large and persistent decrease in the number of non-fatal heroin overdoses and a significant and sustained decrease in the number of deaths where heroin was detected in the deceased. Decreases in heroin overdoses were of a similar magnitude for men and women, but there were bigger decreases among younger age groups and no detectable change among those aged 45 years and older. It is possible that a reduction in heroin availability had a bigger impact on younger than older heroin users' likelihood of overdose. This suggests that older users remained in the market, whereas younger users may have ceased or reduced their use of heroin.

There was no detectable change in ED admissions for cocaine, methamphetamine or benzodiazepine overdose, despite evidence that the use of these drugs increased among some injecting drug users, and despite good evidence of drug substitution.[15,16,21] Neither non-fatal nor fatal overdoses with these other drugs increased to the same extent that heroin-related overdoses decreased. This suggests a number of possibilities: that users did not experience overdoses related to the use of these drugs, that they did not seek the assistance of ED personnel when they did overdose (perhaps because the symptoms were less obvious), or that ED personnel may not have recognised these overdoses. Given the

presence of harm-reduction initiatives to encourage users to call ambulances, and continued free access to emergency health services in NSW, we could not identify other factors that might have affected the number of calls about overdoses.

Our findings also suggested the reduction in heroin supply (and street-level purity) was followed by a decrease in the proportion of drug-related deaths where heroin was the only drug detected. Concomitantly, there was an increase in the proportion of suspected drug-related deaths where heroin was detected in combination with a range of other depressant drugs, and a small increase in the proportion of deaths where no heroin was detected. Overall, however, the total number of suspected drug-related deaths decreased after the reduction in heroin supply. Hence, although heroin contributes to most drug-related deaths in NSW, and despite evidence of drug substitution, heroin seems to be a significant driver of drug-related deaths in NSW.

Our study benefited from the fact that routine data collection systems were in place in NSW, allowing us to examine community-level effects of a significant change in drug availability.

Our study is subject to the flaws that beset all natural experiments in that it is not possible to guarantee that the intervention being studied was the only event that affected drug overdoses in the time period. However, the changes in overdoses we report were remarkably similar to the changes observed in other indicators of drug use [15,16] and harms, such as entry to drug treatment[22] and police incidents for drug possession or use.[23] The possibility of some other event contributing to the changes in overdose was examined and ruled out through extensive crosschecking through key informants, consultation with stakeholders, and analysis of other data sources in the wider project from which this study is drawn.[24,25]

Our findings relied on routine data collections for information on drug overdose, and there may be error associated with the entry of data in such systems. However, there were no indications of any changes in reporting that may have occurred around the time of the heroin shortage.

The ambulance service data are based on attendances at incidents rather than on people, which means that the same person may have accounted for several ambulance callouts. However, previous work has indicated close agreement between trends in ambulance callouts and in opioid-induced deaths as coded by the Australian Bureau of Statistics.[26,27] Further, the data do not include the outcome of the ambulance attendance. Some people may have later died despite receiving assistance from the ambulance officers, resulting in the same overdose being counted as both a non-fatal and a fatal event. Nonetheless, if we assume that these sources of error remain relatively constant over time and area, these data provide potentially useful information on trends in non-fatal overdose.

An obvious question is what caused the reduction in heroin supply, and whether it could be reproduced, either here or in other countries. An examination of the potential reasons for the reduction in supply found that the event was likely to have reflected the confluence of a number of factors, and may be difficult to reproduce here or elsewhere.[28] What our study has shown, however, is that when a reduction in heroin supply occurs it may be associated with significant reductions in mortality from drug use at a community level.

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COMPETING INTERESTS

None identified.

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