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Potential impacts on the incidence of fatal heroin-related overdose in Western Australia: a time-series analysis

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Abstract

In response to the rising concerns about the rate of heroin-related fatalities, overdose prevention campaigns, run by both users' organizations and government agencies, have been implemented in a number of states across Australia. In Western Australia (WA) in mid-1997, various overdose prevention initiatives were implemented. These included the implementation of a protocol limiting police presence at overdose events; the commencement of naloxone administration by ambulance staff; and the establishment of the Opiate Overdose Prevention Strategy (OOPS) which provided follow-up for individuals treated for overdose in emergency departments. This paper reports the results of a multiple linear regression analysis of 60 months of time-series data, both prior to and following the implementation of these interventions, to determine their impact on the number of fatal heroin overdoses in WA. The model employed in the analysis controlled for changes over time in proxy indicators of use and community concerns about heroin, as well as market indicators. The results suggest that, although the interventions implemented have managed to reduce the expected number of fatalities, they have become less successful in doing so as time passes. This has implications for both existing and potential interventions to reduce fatal heroin-related overdose. [Hargreaves K. Lenton S, Phillips M, Swensen G. Potential impacts on the incidence of fatal heroin-related overdose in Western Australia: a time-series analysis. *Drug Alcohol Rev* 2002;21:321–327]

Key words: harm reduction, heroin, interventions, overdose, time-series.

Introduction

Data collected from a number of sources indicates that the availability and use of heroin increased dramatically in Australia during the 1990s [1–4]. As the use of heroin has increased, so too has the incidence of fatal and non-fatal heroin-related overdose. Non-fatal heroin overdoses are a common event among heroin users [5] with a substantial proportion of IDUs having experienced at least one [5–9]. The frequency with which non-fatal overdoses occur appears proportionate to the length of time the individual has been using heroin [6]. There is always the potential for an overdose event to result in a fatality.

Fatal overdose is now considered the main contributor to excess mortality among IDUs in Australia [10,11]. In 1998, heroin overdose accounted for almost 9% of all deaths among people aged 15–44 years across the country [12]. Among young people, aged 15–24 years, heroin overdose accounts for 12% of all male and 13% of all female deaths. Yet another increase in the overdose rate was observed in Australia between 1998 and 1999 with the rate per million population rising from 87.1 to 112.5 per million among those aged 15–44 [13]. The annual number of Australians aged 15–44 years who have died from heroin overdose has risen from 316 in 1990 to 958 in 1999. The majority of heroin-related fatalities occur among older, more experienced and more dependent users who use other drugs in conjunction with heroin, particularly alcohol and/or benzodiazepines [6,8,14–18].

In response to rising concerns about the increased rate of heroin-related drug overdose, overdose prevention campaigns, run by both users' organizations and government agencies, have been implemented in Western Australia (WA) and a number of other Australian

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states. In addition to providing overdose prevention messages, these campaigns provide details on how to manage an overdose, and include training in and information on basic first aid. Many of these campaigns encourage users to call an ambulance and to do so as an initial, rather than a last, response to overdose.

Western Australian situation

WA has witnessed a similar increase in the number of heroin-related fatalities. Deaths rose from 17.7 to 85.0 per million population among those aged 15–44 years between 1990 and 1999, representing an increase from 14 to 73 fatalities, respectively [13]. This increasing rate of fatalities led to the implementation of a range of interventions during 1997. There was considerable concern within the WA drug using community about police attendance at overdoses, which articles in the *West Australian* newspaper at the time [19–21] may have reflected, and perhaps contributed to. Consequently a number of agencies took steps to address this concern. First, discussions between police and drug user representatives resulted in an agreement that police would attend overdoses only if there was a fatality or if attending ambulance staff felt their safety would be placed in jeopardy. This saw the police focus shift away from viewing an overdose as a crime scene towards viewing it as a health issue. The police protocol [22] which put this into effect was distributed through drug user networks in July 1997 in an attempt to allay users' concerns. Secondly, various initiatives focused on the dissemination of overdose prevention information and first aid training to users (eg. the Opiate Overdose Prevention Strategy (OOPS!) Emergency Department (ED) project; the WA Substance Users Association (WASUA), first aid training and outreach services and information on needle packs distributed through pharmacies). Thirdly, ambulances started carrying naloxone as an aid to the management of opioid-related overdose. This was primarily employed to assist where there were multiple overdoses and/or considerable time was required to extricate an individual from their location [23].

Aims

One of the aims of the study was to determine whether the number of ambulance overdose calls had increased in response to the interventions implemented. Further, the study aimed to determine whether these interventions had resulted in a decrease in the incidence of heroin-related deaths.

Method

Western Australian data was examined on a monthly basis for the period January 1996 to December 2000. The analysis was designed to evaluate what impact this range of interventions may have had on the death rate from heroin-related overdose. Thus the number of heroin-related overdose fatalities per month was the dependent variable used in the analysis. A number of variables were examined over the period of the study to determine whether a significant relationship to the number of fatalities existed. These are listed below.

Data included

Ambulance callouts. The number of ambulance callouts as a consequence of overdose was included as a proxy indicator of the number of non-fatal heroin-related overdoses, possibly associated with either higher prevalence of use and/or more frequent use among those who are using heroin. As the WA Ambulance Service only began routinely recording *narcotic* overdoses in their drug overdose records as of July 1998, the number of data points available for analysis was limited. Therefore, data on the total number of drug overdose calls to ambulance (i.e. for both narcotic and non-narcotic drugs) were used as these were correlated highly with the narcotic overdose calls during the period when both sets of data were available (Spearman's $r = 0.697$, $df = 41$, $p < 0.001$). As many of the overdose prevention messages encouraged users to call an ambulance in response to overdose it was decided to examine whether the number of callouts had increased over time and whether there had been any resultant reduction in the number of heroin-related overdose fatalities.

Market factors

To control for the impact of other factors on the death rate (such as changes in the heroin market and/or level of community concern regarding heroin use) proxy measures of these factors were also included as variables in the analysis.

Calls to the Alcohol and Drug Information Service (ADIS). The number of heroin-related calls, from both users and concerned others, made to the ADIS line, a 24-hour information and counselling telephone service, were included. These calls served as a proxy measure of the level of heroin use and/or number of users, and possibly also reflected the level of concern about heroin overdose in the community.

Number of drug charges and purity of seizures. The number of charges for offences relating to the 'possession/use' and 'deal/traffic' of heroin, and the number and purity of heroin seizures submitted for analysis by law enforcement, were utilized as indicators of the drug's availability within the community. Purity levels of seizures less than or equal to 2 g were used with this cut-off chosen as the

size of seizure most likely to represent street level quality and also because it has been used elsewhere [1]. As the number of seizures made per month was unavailable by weight of seizure the total number of seizures analysed, per month, was used.

Period of analysis

The period of analysis contained sufficient data points both before and after the introduction of the range of initiatives already mentioned. In order to maximize the period available for study it is important to point out that some 'unconfirmed' heroin death data were used. The heroin-related deaths reported for January 1996 to December 1998 have been confirmed as such by the coroner, whereas the deaths for 1999 and 2000 are still 'suspected' deaths. 'Suspected' cases were those based on a determination made by police that the death was a heroin-related fatality but there was not yet coronial confirmation. It was decided to use the total dataset as this allowed for a more up-to-date analysis and greater statistical power. Were it to have an effect, the inclusion of the suspected deaths would also run contrary to the hypothesis under investigation, given that it would allow a sufficient period of time following the implementation of the interventions to account for any lag in their impact. Additionally, it also reduced the probability of a Type II error occurring because of the additional data points available for use.

Data analysis

An analysis was conducted to determine what impact the overdose prevention initiatives and strategies implemented in mid-1997 have had on the number of subsequent heroin-related fatalities observed in WA.

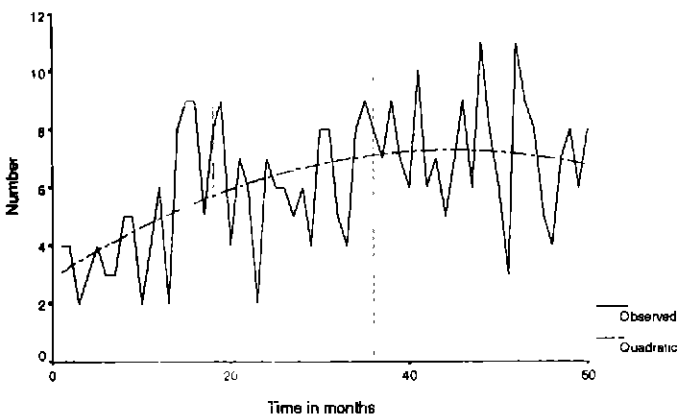

Figure 1. *Trend in heroin deaths over the intervention period (1996–2000). A depiction of the number of heroin-related deaths recorded each month during the period January 1996–December 2000. The vertical line at month 18 represents the point at which the interventions were implemented and the vertical line at month 36 represents the end of the period of confirmed data. The line of best fit, based on a quadratic regression model, is shown.*

This involved the creation of a new variable in a two-step process. First, pre-intervention data were used by employing the multiple linear regression equation to predict or forecast the number of deaths that would have occurred each month if the interventions had not been implemented. Secondly, the actual number of deaths observed per month was subtracted from this predicted number of deaths per month. The difference in these two figures then provides an estimate of the number of lives saved per month during the period of analysis.

The model of best fit developed was non-linear and quadratic in nature and indicated that the number of deaths had peaked and then flattened off during the period of study. This model is presented in Fig. 1, with the first vertical line indicating the time at which the intervention strategies were implemented and the second representing the point at which the data changes from confirmed to suspected fatalities.

Results

Intervention analysis

An intervention analysis was used to determine what, if any, impact the various interventions introduced in mid-1997 may have had on the number of fatalities. This involved the creation of a second model, including a dummy variable, which split the data into a pre- and post-intervention analysis of the trend in heroin-related deaths. The variable representing the period in which the interventions were implemented was then included in the analysis.

As the dependent variable was time-series in nature a Durbin–Watson test was conducted to determine whether any significant positive or negative serial auto-correlation existed among the residuals. The Durbin–Watson statistic was 1.99 ($k = 2$, df $= 59$, $p = 0.0004$) indicating that the heroin-related deaths in the period studied were not serially auto-correlated.

Given the absence of serial auto-correlation it was appropriate to conduct a multiple linear regression analysis (stepwise regression). Following this analysis only the variables representing time (time in months and time squared), the number of ambulance callouts and the interventions were significantly related to the number of deaths per month. These significance levels are reported in Table 1.

In essence this means that, when controlling for changes over time in the heroin market, only time, the number of ambulance callouts and the interventions implemented in an attempt to reduce the number of overdoses were significantly related to the number of overdose fatalities observed in WA during the period of study. The other variables were not significantly correlated with the dependent variable and consequently were unable to predict the number of heroin deaths in our model.

Table 1. *Multiple regression results*

Variables of interest	B	Standard error	*t*	Significance
Time	0.3457	0.0882	3.920	0.0002
Time squared	−0.0038	0.0011	−3.293	0.0017
Ambulance callouts	0.0341	0.0130	2.616	0.0115
Intervention period	−2.4133	1.1216	−2.152	0.0358

Using the analysis to estimate the number of lives saved per month since the interventions were implemented (previously described in the data analysis section) it was possible to determine that the predicted number of fatalities reduced by 8.6 deaths over the post-intervention period. While this translates to an average saving of one life every 5 months for the 3.5 years post-intervention the reality is that virtually all the lives were saved in the first 18 months of this period, as indicated in Fig. 2.

To explore further this waning effect, a comparison of multiple regression results from the two data periods was made. The first analysis used only data based on the 3 years of confirmed deaths, and the second analysis used data for the full 5 years, including the 2 years of suspected death data. The comparison of results confirmed that the impact of the interventions has waned over time, with the impact of the interventions 18 months post-intervention (regression co-efficient = −3.03, p = 0.018) greater than at 3.5 years post-intervention (regression co-efficient = −2.41, p = 0.036).

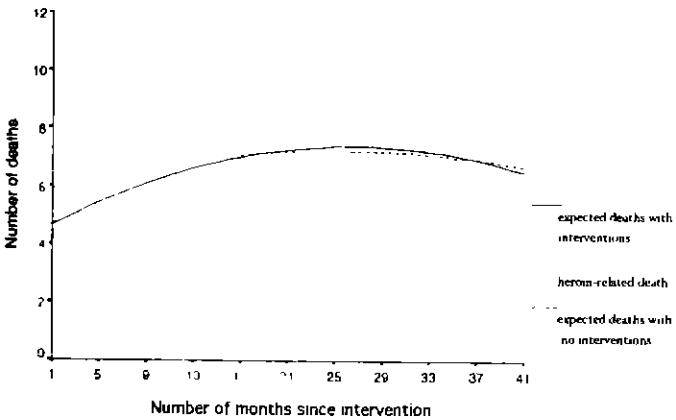

Figure 2. *Estimated intervention impact using comparison of alternative regression models. The expected number of heroin-related deaths per month without the interventions was calculated using a multiple linear regression equation projected from the pre-intervention data, and is represented by the dashed line. The solid line in this figure represents the expected average number of heroin-related deaths per month following the implementation of the interventions. The difference between these lines indicates the impact of the intervention. Note that the difference is greatest in the early post-intervention period.*

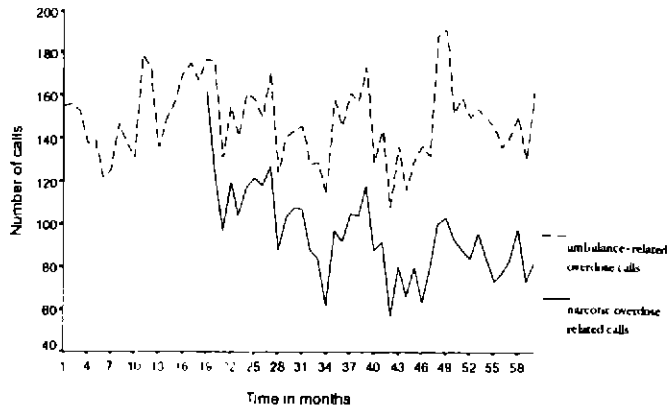

Figure 3. *Relationship of all overdose calls and narcotic-only overdose ambulance calls. This figure represents the number of overdose calls made for an ambulance per month for the period January 1996–December 2000. The dashed line represents calls made for all types of overdose and the solid line represents the proportion of such calls that were made in relation to narcotic overdose.*

As noted previously, one of the aims of the study was to determine whether the number of ambulance overdose calls had increased in response to the interventions. An analysis of the number of ambulance overdose calls was therefore conducted to see if any such increase had occurred and whether it had resulted in a decrease in heroin-related deaths. It appears, however, that ambulance overdose-related calls and deaths are positively related, as indicated by the regression results reported in Table 1. It is likely that both deaths and ambulance callouts are a function of the number of hazardous heroin use events occurring in the community. Both the number and proportion of calls made to the ambulance service in relation to narcotic overdose has also diminished over time (see Fig. 3).

Discussion

Although it was determined that the only significant variables were time, the number of ambulance callouts and the interventions, it is important to note that there has been a decrease in the number of these callouts over time. Additionally, the proportion of overdose-related callouts relating specifically to opioid overdose has fallen. Of greater concern is that the number of ambulance callouts has fallen over this period despite overdose prevention and management programmes encouraging users to call an ambulance as part of their overdose management protocol. Other drug market factors may have impacted on the number of such calls, however, as a re-emergence in the use of amphetamines, particularly methamphetamine, was observed in Perth in the year 2000 [24]. This re-emergence could well have resulted in a reduction in the number of people using opiates, resulting in a decrease in the number of

narcotic overdoses and a subsequent increase in overdoses relating to the use of other drugs.

Regardless of the impact the interventions have had on the number of deaths recorded in WA it would appear that there has been a reduction in the number of such deaths in the latter months of this time-series. Additionally, there has been a recent decrease in the number of heroin-related calls made to the ADIS line. Although the variable representing these calls bore no significant relationship to the number of observed fatalities in our model this could well be due to a time lag between concern about use and the experiencing of a hazardous use event. Taken together these findings suggest that other factors are most probably responsible for the decrease in heroin overdose deaths in the latter months, even though the interventions did reduce the number of such deaths shortly after their implementation. Recent evidence would suggest that the observed reduction in heroin-related fatalities, and the reduction in the number of calls made to ADIS, were most probably associated with the recent decline in heroin availability [24–26].

While an impact on the number of fatalities was observed, the number of lives saved was limited and most of this effect occurred in the 18 months after the interventions were first implemented. Given this, there is obviously more opportunity to reduce the risks of fatal and non-fatal overdose among heroin users. The reduction in the number of ambulance callouts over time does, to some extent, reinforce the waning effect of these interventions, irrespective of the impact any reduced availability of heroin may have had and supports the notion that there are a couple of options available. Either we can examine ways in which to maximize the efficacy of the interventions implemented and re-invigorate them as it becomes evident that their impact is waning, or we can try alternatives, or both.

First, that specific problems inherent in some of the strategies implemented may have existed cannot be discounted. For example, the policy of police non-attendance at overdose may not have been accepted universally by users with the myth of attendance still pervading some sectors of the drug-using community. The potential impact of serious staffing and related work-load issues in the emergency departments at Perth's major hospitals on the efficacy of the OOPS ED project also cannot be discounted. As the main focus of the ED project was to provide an outreach service to individuals who had recently overdosed and been transported to hospital, eligible clients may not have been referred to the service because of these issues.

Secondly, alternative interventions may well have had a much greater impact than those implemented. New approaches to assist in reducing the number of heroin-related fatalities could include a trial of the provision of naloxone to heroin users for peer administration [12,27,28] or the establishment of supervised injecting facilities in locations where open drug markets exist [29]. Although Australia has already embarked on the process of increasing accessibility to a range of pharmacotherapies as a way in which to encourage people into drug treatment [30], a trial of heroin prescription may be an effective addition to the range of pharmacotherapies on offer.

Given that intravenous use of heroin is regarded as a risk factor for overdose [11], strategies aimed at preventing the uptake of heroin use or the transition to injecting could also reduce the incidence of heroin-related overdose, if effective. Consideration should also be given to strategies which are not generally associated with overdose prevention such as cannabis law reform. Evidence from the Netherlands [31,32] suggests that the introduction of the cannabis 'coffee shop' system may have reduced the uptake of injecting drug use among Dutch youth.

While the effectiveness of overdose prevention strategies remains to be seen, the results of this time-series analysis caution that a review of their efficacy over time may be needed to ensure that their impact has not waned. Where this has occurred, re-invigoration or revision to the existing strategies should be made or alternative strategies developed and trialled.

Limitations of the analysis

It is possible that the data chosen for inclusion in the analysis may not have been truly representative of the factors we wished to incorporate, namely heroin availability and the level of use within the community. In general, there was little correlation between any of the proxy measures utilized, with the exception of the crime-related indicators. The number of possession and dealing-related charges were highly correlated ($p = 0.001$). However, it is likely that these measures are representative of the level of police activity in relation to the heroin market, and are consequently imprecise indicators of the heroin market *per se*, as they are affected by operational issues and priorities.

A strong relationship between heroin-related overdose fatalities and the number of ambulance callouts to overdose was expected. Given the attempts made to increase users' willingness to call an ambulance as a means by which to reduce the incidence of fatal heroin-related overdose, the *positive* nature of the relationship was not anticipated. That these two variables probably measure the same event, namely hazardous use incidents, most likely explains the positive nature of this relationship. While it would have been beneficial to utilize ambulance callouts to opioid-

overdose events only, rather than include non-opioid overdose events, the number of data points was limited and would have reduced the amount of data available for analysis. Although a stronger association between heroin-related fatalities and ambulance calls for opioid overdose would be expected, it is unlikely that this would have affected any of the other findings reported.

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