JURISDICTIONAL TRENDS IN OPIOID OVERDOSE DEATHS, 1988-1996

Michael Lynskey & Wayne Hall

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Executive Summary

This report analysed data on opioid overdose mortality between 1988 and 1996 in order to: 1) examine differences between the States and Territories of Australia in the rate of fatal opioid overdose, the rate of increase in fatal overdose and the average age at death from opioid overdose and; 2) estimate the proportion of all deaths over that period which were attributed to opioid overdose.

Data were obtained from the Australian Bureau of Statistics (ABS) on the number of deaths attributed to opioid dependence (ICD 9 codes 304.0, 304.7) and accidental opioid poisoning (ICD 9 codes E850.0, E850.1) for the years 1988 to 1996. Further data was obtained from the ABS on the total number of deaths, the number attributed to suicide, and the age at death. To calculate age and sex-specific mortality rates, data were also obtained on the numbers of men and women of each age between birth and 85 who were resident in each state, and in the whole of Australia, at June 30 of each year between 1988 and 1996.

Between 1995 and 1996 there was a small decrease in the number of opioid overdose fatalities: this decrease could be largely attributed to a drop in the number and rate of female overdose from 110 in 1995 (27.9 per million population) to 86 (20.7 per million population) in 1996. By comparison the rate of male opioid overdose remained stable: In both years there was a total of 440 opioid overdose deaths among males.

The highest rate of fatal overdose occurred in New South Wales, Victoria had the second highest rate and the standardised mortality rate among the remaining States and Territories fluctuated quite markedly. Despite these differences in rates of mortality, all States showed an increase in the rate of overdose mortality between 1988 and 1996. Further analyses suggested that, while the rate of opioid overdose has increased throughout Australia, the rate of increase has been greater in some of the smaller States and Territories than it has in New South Wales or Victoria.

In 1996 approximately 6.5% of all deaths among people aged 15-24 years were due to opioid overdose and approximately 10% of all deaths among those aged 25-34 were attributed to this cause. During the interval from 1988 to 1996 the proportion of deaths attributed to opioid overdose increased. Among individuals aged 25-34 years, the proportion of deaths attributed to opioid overdose was approximately half that attributed to suicide. The rate of increase in the proportion of deaths attributed to opioid overdose was higher than the rate of increase in the proportion of deaths attributed to suicide.

Potential strategies for reducing mortality associated with opioid overdose include: 1) Increasing access to and utilisation of methadone maintenance and other treatment; 2) Educating injecting drug users about the dangers of polydrug use; 3) Encouraging injecting drug users not to inject alone; 4) Encouraging witnesses of opioid overdose to seek medical assistance and; 5) Trialing distribution of naloxone to high risk injectors.

1.0 Introduction

There have been increasing concerns about an apparent increase in heroin use in Australia in recent years. Comprehensive epidemiological data on patterns of heroin use are unavailable, mainly due to problems in collecting information on an illegal and socially disapproved behaviour which is restricted to a small and relatively isolated section of society. Nonetheless, there are a number of reasons for believing that there has been an increase in the number of heroin users in Australia. Evidence in support of this view includes: a) an increase in the numbers and amounts of heroin seized by customs and police (Australian Bureau of Criminal Intelligence, 1997); b) an increase in demand for methadone maintenance and other forms of treatment for heroin dependence (Hall, 1996) and; c) findings, discussed in detail below, that there has been a six fold increase in the rate of fatal opioid overdose since 1979 (Hall & Darke, 1997).

Hall and Darke (1997) examined trends in the number and rate of opioid overdose using national data collected during the interval from 1979 to 1995. Their analyses lead to the following conclusions:

> The number of opioid overdose deaths rose from 70 in 1979 to 550 in 1995. There was a corresponding six-fold increase in the rate (per million of the adult population aged 15 to 44) of fatal overdose from 10.7 in 1979 to 67.0 in 1995. The increase in the rate of fatal overdose was more marked among males (from 15.3 in 1979 to 104.6 in 1995) than among females (from 5.9 in 1979 to 27.9 in 1995).
>
> Overdose mortality rates varied between different jurisdictions. Among males, New South Wales consistently accounted for around a half of all overdose fatalities, and its rate was almost twice that in Victoria, and three times that in the remaining states. The authors did not examine rates of fatal overdose separately for the smaller States and Territories.
>
> The average age at death increased from 24.5 years in 1979 to 30.6 years in 1995. The increase in overdose mortality was greatest among men and women aged 35 to 44 years, and 25 and 34 years. It was lowest among those aged between 15 and 24 years.

The recent increase in the rate of opioid overdose reported by Hall and Darke (1997) has not been limited to Australia and there have been a number of reports documenting similar rises in the rate of fatal opioid overdose in other countries including the Nordic countries (Steentoft et al, 1996), Spain (de la Fuente, 1995; Sanchez et al, 1994), Italy (Davoli et al, 1997), Austria (Risser & Schneider, 1994), the United States (United States Department of Health and Human Services, 1997) and England and Wales (Neeleman & Farrell, 1997).

Research on the causes of overdose, recently reviewed by Darke and Zador (1996), has dispelled a number of misconceptions. Firstly, it is commonly believed that many overdose deaths occur among young, relatively inexperienced heroin users. However, Hall and Darke (1997) found that the average of those dying from overdose in 1995 was 30.6 years. Similarly, Zador, Sunjic and Darke (1996) reviewed the coronial files of all heroin related deaths in New South Wales during 1992 and reported that the average age among males dying from opioid overdose was 30.3 years while among females it was 27.2 years.

Additionally, Zador et al (1996) reported that the majority (80%) of deaths occurred among regular heroin users. Only two of the deaths were identified as occurring among novice heroin users, and both of these deaths were classified by the coroner as suicide.

A second common misconception is that a major cause of opioid overdose is unexpectedly high potency of heroin or alternatively, impurities and contaminants in the heroin. The evidence in favour of this view is, at best, sparse. While there is an association between purity of heroin and rates of fatal overdose (Darke, Hall, Weatherburn, & Lind, submitted), research evidence suggests that many individuals who die by overdose have levels of blood morphine at autopsy which are below the commonly accepted toxic dose. In particular, a number of studies (reviewed by Darke & Zador, 1996) have indicated that the serum blood levels of opioids among victims of overdose are often no higher than the levels of blood opioids among heroin addicts who die from other causes (Monforte, 1977) or among heroin users suffering non fatal overdoses (Aderjan et al, 1995; Fugelstad, 1994; Gutierrez-Cebollada et al, 1994). Similarly, there is little evidence to suggest that contaminants play a major role in the causation of fatal opioid overdoses. For example, Zador et al (1996) found no evidence of contaminants in injecting equipment or at autopsy of the 152 heroin-related deaths examined.

Research has suggested that an important factor contributing to risks of overdose is the concomitant use of opioids with other CNS depressant drugs, particularly alcohol (Goldberger et al, 1994; Manning & Ingraham, 1983; Ruttenber & Luke, 1984; Ruttenber et al, 1990; Walsh, 1991; Zador et al, 1996) and benzodiazepines (Chan et al, 1988; Darke & Zador, 1996; Fugelstad, 1994; Monforte, 1977; Richards et al, 1976; Zador et al, 1996). For example, Zador et al (1996) reported that alcohol was detected in 45% of heroin related deaths and that the mean blood alcohol concentrations among these cases was 0.14g/ 100 ml. Further, they reported a negative correlation between blood morphine and alcohol concentrations, indicating that those individuals who had been drinking alcohol had lower mean blood morphine levels when they died. The association between polydrug use and risks of overdose appears so strong, in fact, that, in their review of the factors associated with overdose, Darke and Zador (1996) suggested that the term "opioid overdose" be replaced by the term "multiple drug toxicity".

One issue which is pivotal to the investigation of overdose mortality, and indeed any cause of death, is the reliability and validity of case ascertainment. There are problems with the classification of opioid-related deaths, particularly those attributed to "overdose". There is, for example, considerable difficulty in distinguishing between the categories of "accidental poisoning", "dependence" (or "narcotism") and suicide (Farrell et al, 1996). The category of "dependence" probably signifies that morphine was detected post-mortem in the blood of a person with a known history of opioid dependence who died some time after self-administering heroin. The uncertainty about the causes and classification of opioid overdose deaths means that distinctions between the ICD-9 codes for deaths due to opioid dependence and accidental opioid poisoning are of limited use. Nonetheless, these two causes of death jointly capture those deaths among young adults in which opioids may have played a contributory role. Trends in the rate of such deaths are therefore worth examining as indicators of changes in the contribution of opioid use to premature death (Hall & Darke, 1997).

Finally, it is important to stress that the figures presented in this report do not represent all opioid related deaths. In particular, English et al (1995) estimate that 9% of suicides in Australia are caused by opiates, basing this on the findings of one study which analysed records of suicides in Western Australia during the interval from 1974 to 1984. If this estimate is accepted, then the proportion of deaths attributed to opioids would be substantially higher than that reported here. For example, in 1996 there were a total of 1845 suicides in individuals aged 15-54 years old. Based on English et al's (1995) estimate, 166 deaths in 1996 could therefore be attributed to suicide caused by opioids. The present report has not, however, included these deaths. It has, instead, focussed solely on deaths due to opioid dependence and opiate poisoning. It can be seen that many of the prevention strategies discussed below apply solely to the prevention of opioid overdose. Different strategies will be more appropriate for preventing suicide.

In the analyses reported in this paper, we follow the methods used by Hall and Darke (1997) in making no distinction between deaths in young adults that have been attributed to opioid dependence and to accidental opioid poisoning. All analyses have been performed on the number of deaths from these two causes among men and women between the ages of 15 and 54 for each year between 1988 and 1996 inclusive.

The aims of this report are to use 1996 mortality data collected by the Australian Bureau of Statistics to update and expand on the analyses reported by Hall and Darke (1997). More specifically, the aims are to:

1. Update analyses of total overdose mortality for the period from 1979 to 1995 by including data on opioid overdose fatalities in 1996.

2. Examine differences between the different States and Territories in Australia in both the rate of fatal overdose and in the rate of increase in fatal overdose between 1988 and 1996.

3. Estimate trends in the average age at death from opioid overdose to see whether there have been any differences between the States and Territories.

4. Estimate the proportion of deaths for each age group which are attributed to overdose and examine trends in this proportion in recent years.

2.0 Methods

Data were obtained from the Australian Bureau of Statistics (ABS) on the number of deaths attributed to opioid dependence (ICD 9 codes 304.0, 304.7) and accidental opioid poisoning (ICD 9 codes E850.0, E850.1) for the years 1988 to 1996 inclusive. Further data were obtained from the ABS on the total number of deaths and the number attributed to suicide during this period. The age at death was obtained for males and females in each jurisdiction and in the whole of Australia. To calculate age and sex-specific mortality rates, data were also obtained from the ABS on the numbers of men and women of each age between 15 and 54 who were resident in each state, and in the whole of Australia, at June 30 of each year between 1988 and 1996 inclusive.

Data on deaths from opioid dependence and accidental poisoning were combined to give the total number of opioid "overdose" deaths occurring in each year for males and females. These procedures were the same as those used by Hall and Darke (1997). The current analyses expanded the age range to include all individuals aged 15-54 years old at the time of death because the cohort analysis in Hall and Darke (1997) indicated that injecting drug users who initiated drug use in the 1970s were continuing to die in their 40s and 50s.

The following statistical analyses were performed. First, the sex and age specific mortality rates were calculated for each year for males and females in four age groupings: 15 to 24 years; 25 to 34 years; 35 to 44 years and; 45 to 54 years. Second, these rates were used to calculate a standardised mortality rate for each year for persons, males and females. Third, overdose mortality over the study period was compared between each of the eight states and territories.

The statistical analyses presented in this report mirror those conducted by Hall and Darke (1997). Firstly, the statistical significance of differences in the rate of opioid overdose over time and between jurisdictions was assessed using methods of multiple logistic regression. In these analyses the log odds of an opioid overdose death occurring were modelled as a function of year and jurisdiction. To examine the extent to which the average age of those dying from opioid overdose differed over time and between jurisdictions a multiple linear regression model was fitted to the data in which the average age of death from opioid overdose was modelled as a function of year, jurisdiction and an interaction between year and jurisdiction. Next, to examine the extent to which the rate of opioid overdose varied by age, data on the age of fatalities were used to divide the sample into four age groups: those aged 15-24 years; those aged 25-34; those aged 35-44; and those aged 45-54 years at the time of death. A multiple logistic regression model was then fitted to the data in which the log odds of death were modelled as a function of age group, year and gender.

Finally, a series of analyses was conducted in which the proportion of all deaths attributed to opioid overdose was calculated using data on the number of opioid overdose deaths and the total number of deaths in each age group in each year. A series of multiple logistic regression models was then fitted to the data to examine the extent to which the proportion of deaths attributed to opioid overdose varied with year, gender and age group.

3. Results

3.1. Overdose Mortality - 1996

Hall and Darke (1997) estimated that by 1995 the number of fatal overdose deaths among individuals aged 15-44 years had increased to 550, representing a standardised mortality rate of 67.0 per million population. Examination of the data from 1996 reveals that there was a total of 526 fatal opioid overdoses among adults aged 15-44 years in Australia which equates to a standardised mortality rate of 63.0 per million population. Comparison of the 1996 data with those reported by Hall and Darke (1997) shows that between 1995 and 1996 there was a small decrease in the number of opioid overdose fatalities: this decrease could be largely attributed to a drop in the number and rate of female overdose from 110 in 1995 (27.9 per million population) to 86 (20.7 per million population) in 1996. By comparison, the rate of male opioid overdose remained stable: In both years there was a total of 440 opioid

overdose deaths among males representing a mortality rate of 104.6 per million in 1995 and 104.7 per million in 1996.

While the data described above may suggest that the rate of opioid overdose fatality peaked in 1995 and started to decline, there are a number of provisos that should be placed on this conclusion. In particular, it is possible that, in the long term, the rate of overdose will continue to increase and that the slight decrease reported in 1995 does not reflect a long term decrease in the rate of fatal overdose. It is clearly too early to be able to tell which is the case.

3.2. State and Territory Differences in the Rate of Fatal Opioid Overdose

To examine variations in the rate of fatal opioid overdose between the States and Territories a series of analyses was conducted in which the rate of fatal overdose between the States were compared. Due to the small base rate of the outcome studied, and the smaller populations in some of the States and Territories, these analyses were restricted to data collected since 1988. This covers the period when there has been a dramatic increase in both the number and rate of fatal overdose in Australia. For similar reasons the age range has been expanded to include all individuals aged 15-54 years old at the time death. Finally, data for each of the States and Territories is not presented separately for each gender because of the relatively small number of female deaths in the less populous States and Territories.

To examine the extent to which these changes in the definition of overdose (and particularly the increase in the age range studied) may have affected the substantive conclusions of previous analyses, Table 1 displays the numbers of opioid related overdoses which have occurred in the whole of Australia among both males and females since 1988. The results displayed in this Table are broadly similar to those reported by Hall and Darke (1997) although there are a slightly higher number of deaths in each year due to the extension of the age range to include individuals aged 45-54 years. They lead to the following conclusions:

1. Firstly, there has been a steady increase in the number of overdose fatalities among people aged 15-54 years since 1988. In 1988 a total of 351 individuals died of overdose and this had increased to 557 in 1996.

2. Despite this general rise over the period there was a slight decline in the number of overdose fatalities between 1995 and 1996. Using the expanded age range there was a total of 582 fatal overdose deaths in 1995, corresponding to a standardised mortality rate of 55.3 per million population. This decreased to 557 (52.2 per million population) in 1996.

3. The Table also shows that there were quite considerable gender differences in the numbers of overdose fatalities. Over the nine year period from 1988 to 1996, there were nearly four times more males than females who died from opioid overdose.

Table 1: Number of fatal opioid overdoses by gender among adults aged 14-54, 1988-1996.

Year	Males	Females	Total
1988	269	82	351
1989	240	67	307
1990	252	69	321
1991	194	56	250
1992	263	73	336
1993	301	73	374
1994	339	86	425
1995	465	117	582
1996	462	95	557
Total Deaths	2785	718	3503

The number and rate (per million population) of fatal overdose among individuals aged 15-54 years old at the time of death are shown for the whole of Australia combined and separately for each individual State and Territory in Tables 2 (number of fatal overdoses) and 3 (rate of fatal overdose per one million population). These analyses were not conducted separately for male and females as the small base rate of the outcome and the low population in some States and Territories made any further subdivision of the data unreliable.

The data summarised in these Tables leads to the following general conclusions:

1. Firstly, the data in Table 2 demonstrates the difficulties in attempting to make comparisons between the States and Territories with any great precision. Specifically, in some of the less populous States there were relatively few fatal overdose deaths in any particular year. Consequently, small changes in the number of fatal overdose deaths produced large fluctuations in the rate of fatal overdose in that State or Territory. Table 3 shows apparently large annual fluctuations in the rate of fatal overdose in Tasmania, Australian Capital Territory and Northern Territory. Table 2 indicates that these fluctuations were due to small changes in the numbers of fatal overdose deaths in those jurisdictions.

2. Secondly, statistical analysis of the data in Table 3 indicated significant differences between the States and Territories in the rate of fatal overdose. In particular, throughout the nine year period studied, the highest rate of fatal overdose occurred in New South Wales, while Victoria had the second highest rate of fatal overdose. The standardised mortality rate among the remaining States and Territories fluctuated quite markedly.

3. Finally, inspection of the results in Table 3 suggests that the rate of increase in opioid overdose deaths varied between jurisdictions. Specifically, while the rate of fatal opioid overdose increased in each of the States and Territories during the period from 1988 to 1996, the rate of increase was higher in some jurisdictions than in others. In particular, examination of the results in Table 3 suggests that the rate of opioid overdose has increased more markedly in South Australia, Western Australia, Tasmania, Northern Territory and Australian Capital Territory than it has in New South Wales, Victoria or Queensland. Due to the small numbers of deaths in the less populous States it was not possible to fit a model to the data containing an interaction between State and Year. However, examination of the odds ratios linking year to rate of opioid overdose deaths for each of the individual States, presented in the statistical Appendix, confirms the general impression that the rate of increase in opioid overdose deaths has been greater in the less populous States and Territories than it has in New South Wales or Victoria.

Table 2: Number of overdose deaths by State/ Territory, 1988-1996 among persons aged 15-54 years.

Year	Australia	NSW	Victoria	Queensland	South Australia	Western Australia	Tasmania	Northern Territory	ACT
1988	351	204	99	16	12	18	0	0	2
1989	307	158	99	19	8	18	1	2	2
1990	321	196	79	8	19	14	5	0	0
1991	250	146	64	9	13	13	3	0	2
1992	336	182	79	18	30	22	0	1	4
1993	374	188	86	23	41	24	5	2	5
1994	425	209	97	37	32	38	4	5	3
1995	582	273	140	42	38	70	6	0	13
1996	557	260	145	32	32	64	5	2	17

Table 3: Standardised mortality rates (per 1,000,000 population) for overdose deaths by State/ Territory, 1988-1996 among persons aged 15-54 years.

Year	Australia	NSW	Victoria	Queensland	South Australia	Western Australia	Tasmania	Northern Territory	ACT
1988	36.6	62.5	39.9	10.1	14.9	19.6	0	0	11.4
1989	31.3	47.5	39.3	11.6	9.8	19.2	3.9	19.2	11.4
1990	32.2	58.2	30.8	4.7	23.1	14.6	19.1	0	0
1991	24.8	42.8	24.7	5.2	15.7	13.4	11.4	0	10.8
1992	32.9	52.8	30.3	10.1	35.9	22.4	0	9.2	21.1
1993	36.3	54.3	33	12.6	48.9	24.1	18.8	18.3	25.9
1994	40.9	59.9	37.1	19.7	38.1	37.7	15	45.5	15.4
1995	55.2	77.4	53.4	21.8	45.1	68.1	22.5	0	66.2
1996	52.2	72.7	54.8	16.2	37.9	61.1	18.7	17.7	85.6

3.3. The Average Age at Death from Opioid Overdose in Different States and Territories

A common belief is that the majority of individuals who die by opioid overdose are young, relatively inexperienced opioid users. Indeed, it has often been assumed that inexperience is an important factor which contributes to risks of overdose. However, more recent research has established that the majority of individuals who die by overdose are older users who often have a long history of opioid use. This was clearly demonstrated by the findings of Hall and Darke (1997) who reported that the average age of people who died by opioid overdose in 1995 was 30.6 years. Further, their analyses revealed that, since 1979, there has been a steady increase in the average age of overdose fatalities from 24.5 years in 1979 to 30.6 years in 1995.

The average age at death of overdose fatalities in each State or Territory during the period from 1988 to 1996 is displayed in Table 4. To examine the extent to which the average age at death varied by year and jurisdiction a multiple linear regression model was fitted to the data. The results of this analysis are summarised below:

1. *Year and age of fatality*. Firstly, in confirmation of the results reported by Hall and Darke (1997), there has been a significant increase in the age at death in recent years: In 1988 the average age of those dying from opioid overdose was 26.8 years but this had risen to 31.0 years by 1996.

2. *State/ Territory differences*. Analyses indicated that there were no significant differences between the States and Territories in the average age of people dying from opioid overdose.

3. *Interaction between State and year*. Finally, but importantly, the analysis suggested that there was no statistically significant interaction between State and year. This indicates that the rise in average age at death observed for the combined Australian data was consistent for each of the individual States and Territories.

Table 4: Mean age at death (years) for overdose deaths by State/ Territory, 1988-1996 among persons aged 15-54 years.

Year	NSW	Victoria	Queensland	South Australia	Western Australia	Tasmania	Northern Territory	ACT
1988	27.8	27.4	28.6	26.7	28.7	-	-	32.0
1989	28.7	28.4	28.5	28.4	30.1	26.0	33.0	30.0
1990	28.1	28.2	31.4	30.8	31.9	30.0	-	-
1991	30.8	27.8	30.8	29.3	33.8	24.3	-	27.0
1992	30.1	29.6	29.8	30.1	30.6	-	34.0	23.5
1993	31.0	30.3	31.0	30.2	31.5	33.0	33.5	26.6
1994	30.6	29.8	32.1	29.5	29.9	28.0	36.0	40.7
1995	32.4	29.1	29.1	31.2	31.6	26.5	-	26.0
1996	31.5	29.1	33.2	30.8	32.4	24.6	36.5	31.7
1988-1996	30.3	28.9	30.6	30.1	31.3	27.9	35.0	29.3

Concerns have focussed on the extent to which there may have been an increase in the number of young people who die by opioid overdose in recent years, particularly in the last five years or so. These concerns have been motivated, at least in part, by suggestions that there has recently been a rapid rise in the number of young people using heroin.

To examine the extent to which the growth in the rate of fatal overdose described above may have varied for people of different ages, a series of analyses was conducted to compare the rate of fatal overdose among males and females aged 15-24 years, 25-34 years; 35-44 years and 45- 54 years. These data are summarised in Table 5. Statistical analysis of these data lead to the following general conclusions:

1. Firstly, there was evidence of a significant ($p<.001$) gender difference in the rate of opioid overdose. Across all four age groups the rate of overdose mortality was consistently higher among males than females. This finding is consistent with the finding, discussed above, that the overall rate of overdose mortality among males is approximately four times higher than the corresponding rate among females.

2. Secondly, in confirmation of previous results, there was a significant ($p<.001$) effect for year, indicating that the rate of fatal opioid overdose increased from 1988 to 1996.

3. Additionally, there was evidence of a significant ($p<.001$) difference in the rate of opioid overdose between different age groups: rates of fatal overdose were highest among those aged 25-34 years and lowest among those aged 45-54 years.

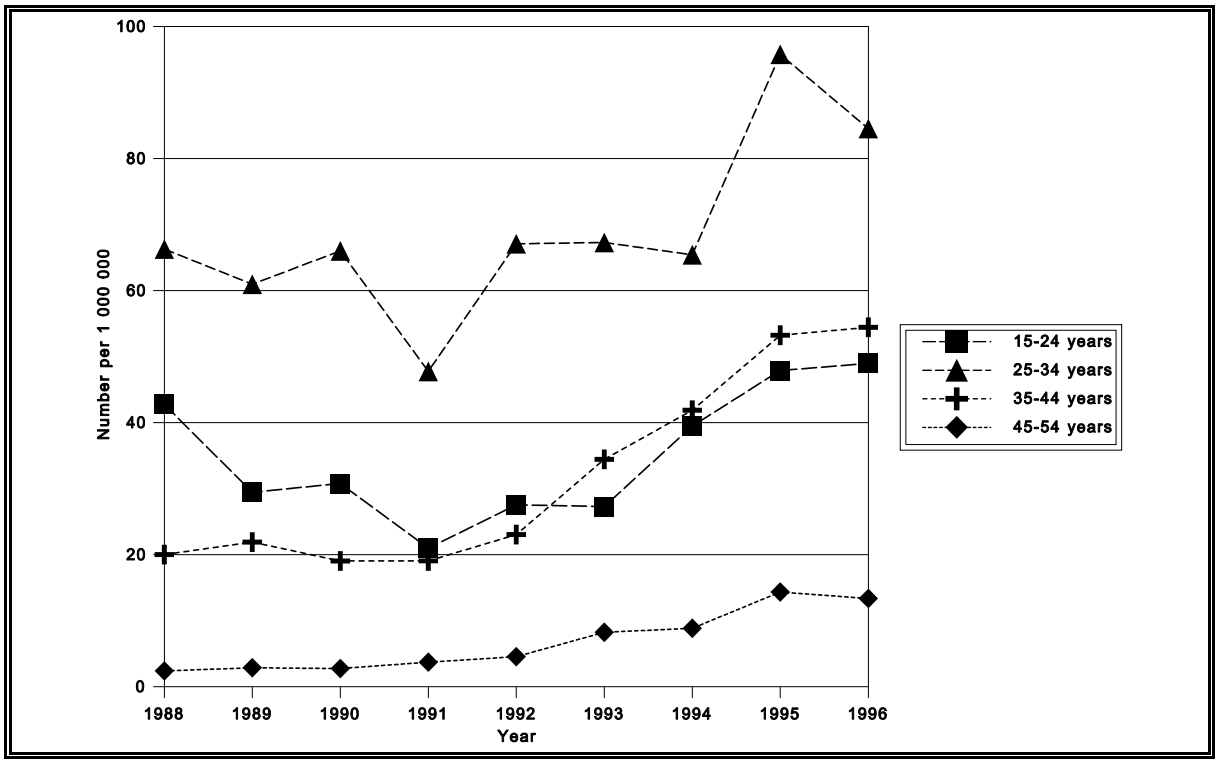
4. Finally, although it was not possible to fit a model containing interaction terms to the data, visual inspection of Table 5 suggests that, while the rate of overdose has increased in all four age groups, the *rate of increase* in fatal overdose has been greater in the older age groups (those aged 35-44 years and 45-54 years old). This finding may explain the apparent discrepancy between concerns about a rise in the number of fatal overdoses among youth and the steady increase in the average age of those dying from overdose. Specifically, while there has been an increase in the number of young people suffering fatal overdoses, there has been an even greater increase in the number of such deaths among older people.

Table 5: Rate (per 1,000,000 population) of fatal opioid overdoses by age by gender among adults aged 14-54, 1988-1996.

Year	15-24 Years		25-34 Years		35-44 Years		45-54 Years	
	Males	Females	Males	Females	Males	Females	Males	Females
1988	53.7	31.3	107.6	24.4	34.7	5.0	3.5	1.2
1989	36.4	22.2	96.5	23.4	39.4	4.0	4.5	1.2
1990	39.1	22.1	108.5	25.0	34.7	3.1	5.4	0
1991	32.0	9.6	72.7	22.7	31.1	6.9	5.2	2.2
1992	40.5	14.1	103.6	30.4	40.7	5.3	5.0	4.1
1993	40.0	14.1	111.1	23.4	53.9	15.0	15.2	1.0
1994	61.6	16.5	102.5	28.3	68.3	15.6	14.6	2.9
1995	64.1	30.9	159.8	32.6	90.6	16.0	22.0	6.4
1996	79.0	17.5	141.8	27.3	91.9	17.1	18.7	7.9

Figure 1 shows the rate of fatal opioid overdose among persons aged 15 to 24 years; 25-34 years; 35-44 years and 45-54 years during the interval from 1988 to 1996. The results in this Figure generally confirm the above conclusions. In particular, while there were clear differences between the four age groups in the rate of opioid overdose, there was evidence of an increase in the rate of opioid overdose for each of the age groups over the period from 1988 to 1996.

Figure 1: Rates of fatal opioid overdose, per 1 000 000 population, amongst adults aged 15 to 54 years, 1988 to 1996.



3.4. The Proportion of Deaths Attributed to Opioid Overdose

Table 6 shows the percentage of all deaths among males and females aged 15-54 years old that were attributed to opioid overdose during the interval from 1988 to 1996. The data presented in this Table were analysed using methods of logistic regression analysis and the results of this analysis can be summarised as follows:

1. Firstly, among individuals aged 15-54 years old in 1996, one in every 20 deaths (4.9%) was attributed to opioid overdose.

2. There were consistent and statistically significant ($p<.001$) gender differences in the proportion of deaths attributed to opioid overdose. For each year from 1988 to 1996 the proportion of male deaths attributed to opioid overdose was 1.2 to 1.7 times higher than the proportion of female deaths attributed to this cause. These ratios are less than the ratio of mortality rates because more males die from other causes, such as suicide and motor vehicle accidents.

3. There has been a statistically significant ($p<.001$) increase in the proportion of deaths attributed to opioid overdose during the interval from 1988 to 1996: In 1988, 3.1% of all deaths amongst those aged 15-54 years were attributed to opioid overdose but this had increased to 4.9% of all deaths by 1996.

Table 6: Percentage of all deaths that were attributed to opioid overdose by gender among adults aged 15-54, 1988-1996.

Year	Males	Females	Total
1988	3.31	2.88	3.14
1989	2.97	2.51	2.81
1990	3.16	2.67	3.00
1991	2.53	1.83	2.30
1992	3.47	2.73	3.20
1993	3.99	2.72	3.60
1994	4.54	3.34	4.20
1995	5.88	4.18	5.35
1996	5.88	3.51	5.22

Table 7 displays the extent to which the proportion of deaths attributed to overdose varies with age for people aged 15-24 years, 25-34 years, 35-44 years and 45-54 years. These results suggest the following conclusions:

1. Firstly, there was a significant ($p<.001$) age difference in the proportion of deaths attributed to opioid overdose: The highest proportion of deaths attributed to this cause occurred in those aged 25-34 years, among whom approximately 10% of all deaths in 1996 were attributed to opioid overdose.

2. Secondly, in confirmation of previous findings that there has been an increase in the rate of opioid overdose in recent years, there has been a significant ($p<.001$) increase in the proportion of all deaths attributed to opioid overdose. Specifically, the proportion of all deaths attributed to opioid overdose among those aged 15-24 years rose from 4.20% in 1988 to 6.44% in 1996; among those aged 25-34 years it rose from 6.69% to 9.96%; among those aged 35-44 years it rose from 1.59% to 4.26% and among those aged 45-54 years it rose from 0.07% to 0.50%.

3. Finally, there was some evidence to suggest that, although the proportion of deaths attributed to opioid overdose has increased in all age groups, the rate of this increase differed between age groups. In particular, the rate of increase in the proportion of deaths attributed to opioid overdose appears to have been greatest amongst older age

groups.

Table 7: Percentage of all deaths that were attributed to opioid overdose by age among adults aged 15-54, 1988-1996.

Year	15-24 Years	25-34 Years	35-44 Years	45-54 Years
1988	4.20	6.69	1.59	0.07
1989	3.27	6.16	1.74	0.09
1990	3.51	6.75	1.61	0.10
1991	2.41	5.19	1.50	0.12
1992	3.32	7.41	1.92	0.16
1993	3.58	7.74	2.79	0.30
1994	5.47	7.73	3.28	0.34
1995	6.03	10.65	4.15	0.60
1996	6.44	9.65	4.26	0.50

Finally, Table 8 compares the proportion of deaths attributed to opioid overdose with the proportion of deaths attributed to suicide in each age group (15-24 years; 25-34 years; 35-44 years and; 45-54 years). Suicide is now the leading cause of death among Australian youth (Baume, 1997) and, as a consequence, considerable resources have been devoted to researching the causes of suicide and intervening to prevent suicide. This comparison suggests the following conclusions:

1. Firstly, in confirmation of previous research findings, a substantial proportion of deaths in all age groups are due to suicide: among those aged 15-34 years old approximately one fifth of all deaths were attributed to suicide. While the proportion of deaths attributed to suicide declines in the older age groups, it is still the case that a substantial proportion of deaths in these age groups are attributed to suicide: approximately one in every seven deaths (14.57%) among those aged 35-44 years old and just over one in every 20 deaths (5.75%) among those aged 45-54 years.

2. Opioid overdose accounts for substantially fewer deaths but a sizeable proportion of all deaths are still attributed to this cause. Among those aged 25-34 years (the peak age of risk for death by opioid overdose) the rate of death due to opioid overdose is almost half the rate of death due to suicide. Furthermore, the proportion of deaths among those aged 15 to 24 years due to opioid overdose is almost one third of that due to suicide. Figure 2 shows the proportion of deaths among those aged 15-34 attributed to suicide and opioid overdose.

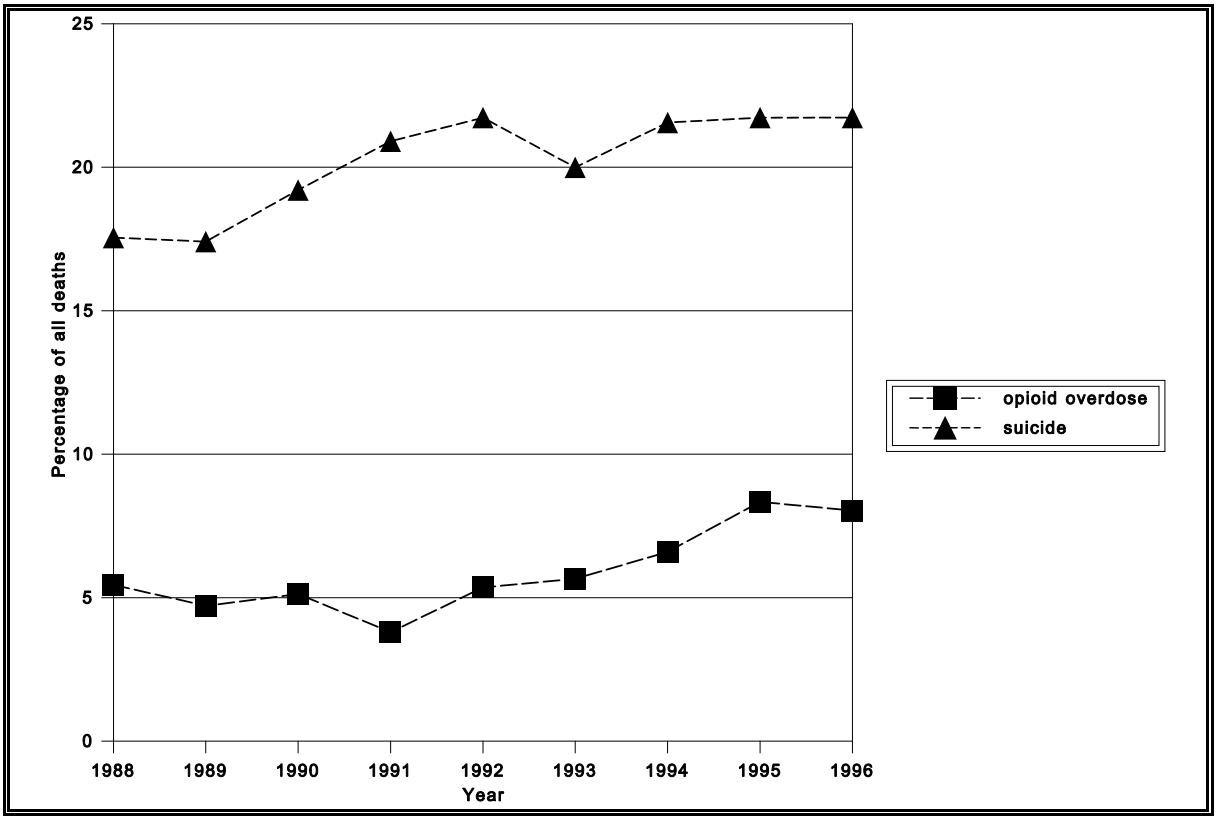
3. There was evidence of significant ($p<.001$) differences between age groups in the proportions of all deaths attributed to both suicide and to opioid overdose. The

proportions of deaths attributed to both these causes were highest amongst those aged 25-34 years and lowest amongst those aged 45-54 years.

4. Additionally, Table 8 indicates that there has been an increase in the proportion of deaths attributed to both suicide and opioid overdose during the period from 1988 to 1996. Statistical analysis of this data revealed significant associations between year and the proportion of deaths attributed to both suicide (OR = 1.035, 95% CI = 1.028 - 1.042, $p < .001$) and opioid overdose (OR = 1.112, 95% CI = 1.097 - 1.127, $p < .001$).

5. Finally, the rate of increase in the proportion of deaths attributed to suicide since 1988 has been less than the rate of increase in the proportion of deaths attributed to opioid overdose. Specifically, comparison of the odds ratios linking year of death to proportion of deaths attributed to suicide (OR = 1.035, 95% CI = 1.028 - 1.042, $p < .001$) and opioid overdose (OR = 1.112, 95% CI = 1.097 - 1.127, $p < .001$) indicates that these odds ratios have non-overlapping confidence intervals.

Figure 2: Proportion of all deaths attributed to overdose and suicide amongst persons



aged 15 to 34 years, 1988 to 1996.

Table 8: Comparison of proportion of all deaths that were attributed to opioid overdose with the proportion of deaths attributed to suicide by age among adults aged 14-54, 1988-1996.

Year	15-24 Years		25-34 Years		35-44 Years		45-54 Years	
	Overdose	Suicide	Overdose	Suicide	Overdose	Suicide	Overdose	Suicide
1988	4.20	17.19	6.69	17.90	1.59	12.04	0.07	4.85
1989	3.27	15.79	6.16	19.03	1.74	10.66	0.09	4.67
1990	3.51	19.29	6.75	19.12	1.61	11.92	0.10	4.54
1991	2.41	21.42	5.19	20.41	1.50	14.29	0.12	5.52
1992	3.32	22.65	7.41	20.80	1.92	12.66	0.16	5.45
1993	3.58	20.31	7.74	19.70	2.79	10.58	0.30	5.50
1994	5.47	22.37	7.73	20.74	3.28	12.61	0.34	5.56
1995	6.03	21.11	10.65	22.35	4.15	13.66	0.60	5.95
1996	6.44	21.23	9.65	22.22	4.26	14.57	0.54	5.75

4. Discussion

In this report we have used national mortality data on fatal opioid overdose during the interval from 1988 to 1996 to examine: 1) the extent to which there has been any change in the number and rate of fatal opioid overdose from 1995 to 1996; 2) the extent to which there are State or Regional differences in the rate of overdose; 3) the extent to which there may be jurisdictional differences in the age of death from opioid overdose; 4) the proportion of deaths in all age groups that can be attributed to opioid overdose. The major findings of these analyses and their implications are discussed below.

4.1. Summary of Findings.

4.1.1 The Rate of Opioid Overdose in 1996.

Comparison of the number of opioid related overdose deaths between 1995 and 1996 revealed that there was a small decrease in the number of opioid overdose fatalities: from 550 (67.0 per million) in 1995 to 526 (63.0 per million) in 1996. This small decrease could be largely attributed to a drop in the number and rate of female overdose from 110 in 1995 (27.9 per million) to 86 (20.7 per million) in 1996 while the rate of male opioid overdose remained static (440 deaths in both 1995 and 1996).

While these findings may suggest that the rate of opioid overdose fatality peaked in 1995 and has started to decline, it would be premature to draw this conclusion. In particular, it is possible that, in the long term, the rate of overdose will continue to increase and that the slight decrease reported in 1995 does not reflect a long term decrease in the rate of fatal overdose. There was, for example, a comparable decline in the number and rate of opioid related mortality from 1990 to 1991 but, despite this temporary decline, the rate of fatal opioid deaths increased thereafter. Further monitoring of the rate of fatal overdose deaths throughout Australia will need to be conducted to assess long-term trends in overdose mortality and determine the extent to which the rising trend in overdose mortality rate between 1979 and 1995 continues.

4.1.2. Jurisdictional Differences in the Rate of Opioid Overdose.

The analyses presented above indicated jurisdictional differences in the rate of fatal overdose. In particular, throughout the nine year period studied, the highest rate of fatal overdose occurred in New South Wales while Victoria had the second highest rate of fatal overdose. The standardised mortality rate among the remaining States and Territories fluctuated markedly, making it difficult to make accurate comparisons of rates. Much of these fluctuations can be attributed to the relatively small numbers of fatal overdose and the low population sizes in the smaller States and Territories.

Despite these jurisdictional differences in rates of mortality attributed to fatal overdose, there were also a number of broad similarities in trends between the different States and Territories. Importantly, over the nine year period of the study there has been a rise in the rate of fatal opioid overdose in each of the eight States and Territories. However, further analyses indicated that the rate of increase has been greater in South Australia, Western Australia, Tasmania, Northern Territory and Australian Capital Territory than in New South

Wales, Victoria or Queensland.

4.1.3. The Average Age of Individuals Dying from Opioid Overdose.

A common misconception is that the majority of individuals who die of opioid overdose are young, relatively inexperienced opioid users. Indeed, it has often been assumed that inexperience is an important factor which contributes to risks of overdose. However, more recent research has established that the majority of individuals who die of overdose are older users who often have a long history of opioid use (Darke & Zador, 1996; Hall & Darke, 1997).

The analyses reported here generally confirmed the findings reported by Hall and Darke (1997): in 1996 the average age of people who died from opioid overdose was 31.0 years. Additionally, there was evidence of a significant gender effect with males being on average approximately two years older (30.4 years) than females (28.6 years). Analyses which examined State and Territory differences in the average age at death by opioid overdose revealed that, while there were some regional variations in the average age at death by opioid overdose, the following general trends held true across each of the eight States and Territories:

> Firstly, the average age of people dying from opioid overdose in each jurisdiction was in the region of 30 years indicating that, throughout Australia, the majority of deaths did not occur among youth but among older users who were likely to have been using opioids for some time. While there were some variations between the jurisdictions in the average age of death, which ranged from 27.9 years in Tasmania to 35.0 years in the Northern Territory, the precision of these estimates can be questioned due to the small sample size in some of the less populous States and Territories.
>
> Secondly, there has been an increase in the average age of people dying from opioid overdose in each of the eight States and Territories. Again, this finding confirms the conclusions of Hall and Darke (1997) and indicates that this increase has occurred throughout Australia.
>
> Finally, there was no evidence to suggest that the increase in the average age of death from opioid overdose has varied between jurisdictions. Instead, the evidence suggested that the average age of death from opioid overdose has risen equally throughout Australian States and Territories.

Concern about the extent to which there may have been an increase in the number of young people who die by opioid overdose in recent years has been motivated by fear of a rapid rise in the number of young people using heroin. While evidence is unclear, these concerns are supported, in part, by increases in the amounts of heroin being imported into Australia (Australian Bureau of Criminal Intelligence, 1997), an increase in the demand for methadone maintenance and other forms of treatment for opioid dependence (Hall, 1996) and by a steady decline in the average age of initiation to heroin use (Lynskey and Hall, submitted). Further evidence from the Illicit Drug Reporting System has suggested that there has been a decline in the average age of injecting drug users in recent years (Hando et al, 1997).

However, the current findings indicated that rates of fatal overdose were highest among those aged 25-34 years and that the rate of increase in fatal overdose was greatest in those aged 35-44 and 45-54 years old. These findings may help reconcile the apparent discrepancy between a rise in the number of fatal overdoses among youth and a steady increase in the average age of those dying from overdose. Specifically, while there has been an increase in the number of young people suffering fatal overdoses, there has been an even greater increase in the number of older people dying from overdose.

4.1.4. The Proportion of Deaths Attributed to Opioid Overdose.

The data indicated that a substantial proportion of all deaths in the 15-54 year age group could be attributed to opioid overdose. In 1996, 6.5% of all deaths among people aged 15-24 years and 10% of those amongst people aged 25-34 were attributed to this cause. The proportion of deaths attributed to opioid overdose among older aged groups was considerably lower (0.5% in those aged 45-54 years) reflecting a combination of two factors: a reduced rate of opioid overdose among these age groups and an increased frequency of mortality from other causes.

Secondly, between 1988 and 1996 the proportion of deaths in each of the four age groups attributed to opioid overdose increased. Among those aged 15-24 years the proportion rose from 4.2% in 1988 to 6.4% in 1996. It rose from 6.7% to 10.0% among those aged 25-34 years, from 1.6% to 4.3% among those aged 35-44 years and from 0.1% to 0.5% among those aged 45-54 years. This trend underscores previous findings that there has been an increase in the number and rate of opioid overdose and highlights the needs to develop interventions to reduce the number of opioid overdose fatalities.

Finally, comparisons of the rate of mortality due to opioid overdose with the corresponding rate of mortality due to suicide (widely recognised as the leading cause of death among Australian youth) indicated that the proportion of deaths attributed to opioid overdose was also substantial. Among individuals aged 25-34 years the proportion of deaths attributed to opioid overdose was approximately half that attributed to suicide. Moreover, the proportion of deaths attributed to suicide has increased at a slower rate in recent years than the proportion of deaths attributed to opioid overdose.

These comparisons suggest that the relative concern expressed about opioid overdose, and the resources devoted to preventing them, are perhaps disproportionately less than the resources devoted to suicide prevention. While improved efforts need to be made to prevent suicide, more effort also needs to be devoted to the prevention of opioid overdose. It is probable that the relative neglect of this issue until the very recent past reflects the marginalised and socially isolated status of injecting drug users within Australian society.

4.2. Implications of Results.

4.2.1 Are we Facing an Epidemic of Fatal Overdose in 10 Years Time?

Hall and Darke (1997) reported that most of the increase in opioid overdose mortality between 1979 and 1995 occurred among persons who initiated heroin use in the 1970s and 1980s. They concluded that, if the mortality experience of recent initiates replicated that of the two earlier age cohorts, there will be another epidemic of overdose mortality in 10 to 15 years.

Given this possibility it is clear that increased efforts to prevent and reduce the number of opioid overdoses need to be made and, despite the apparent decline in the number of fatal overdoses between 1995 and 1996 it would be unwise to become complacent about the issue of opioid overdoses. A number of potential strategies for reducing mortality due to opioid overdose are discussed below.

4.2.2 Prevention of Opioid Overdose.

Given the high prevalence of opioid overdose and the possibility of a continued increase in overdose mortality, there is a need to develop, implement and evaluate effective strategies to prevent or reduce the occurrence of opioid overdose. There are a number of strategies which are likely to be successful in reducing the rate of opioid overdose.

1. Increasing Access and Utilisation of Methadone Maintenance and other Treatment. Given that older, long term users are at greatest risk of fatal overdose, one strategy for reducing fatalities would be to increase the number of older heroin users who are enrolled in methadone maintenance and other treatment. The risk of overdose death is substantially reduced among individuals enrolled in methadone maintenance treatment (Caplehorn, Dalton, Cluff & Petrenas, 1994; Gearing & Schweitzer, 1974). For example, Gearing & Schweitzer (1974) documented mortality among 17,000 patients receiving methadone maintenance. Findings indicated that the mortality rate among methadone maintenance patients (7.6 per 1,000) was similar to that in the general population (5.6 per 1,000) but was significantly lower than the mortality rate among those who left the methadone maintenance program (28.2 per 1,000) and opioid users not in treatment (82.5 per 1,000). Similarly, an Australian study of 307 heroin users enrolled in a methadone maintenance program in the early 1970's revealed that they were nearly three times more likely to die when they were not receiving methadone than when enrolled on the methadone program (Caplehorn et al, 1994).

An increase in the number of people enrolled in methadone maintenance treatment has already occurred over the past decade (Hall, 1996). However, more effort may need to be made to enrol those older users who have not been attracted to methadone treatment. This requires the trial and evaluation of alternative maintenance pharmacotherapies (Mattick, Oliphant, Ward & Hall, 1998). These include levo-alpha acetyl methadyl (LAAM) and buprenorphine. LAAM has long acting metabolites that block withdrawal and craving for up to 72 hours and thus, unlike methadone which needs to be taken on a daily basis, needs to be taken only two or three times per week. Buprenorphine is a partial agonist at the mu receptor and an antagonist at kappa receptors. Because it is a partial agonist buprenorphine produces only limited opioid effects and thus the risk of overdose is reduced. Additionally,

buprenorphine effectively prevents the effects of other opioids and thus reduces the likelihood of the concurrent use of heroin and other opioids. As with both methadone and LAAM, patients who use buprenorphine become dependent on it but withdrawal from buprenorphine is comparatively mild. Clinical trials of the efficacy of these alternative pharmacotherapies are currently being conducted throughout Australia.

2. Educating Injecting Drug Users about the Dangers of Polydrug Use. A recurrent finding in the literature has been that risks of fatal opioid overdose are heightened by the concurrent use of other CNS depressant drugs, particularly benzodiazepines and alcohol. It is therefore important that heroin users are informed about the risks of combining heroin with alcohol and other depressant drugs. A preliminary trial of a peer based intervention to inform heroin users of these dangers has recently been conducted in South Australia.

3. Encouraging Injecting Drug Users not to Inject Alone. Heroin users also need to be discouraged from injecting in the streets or alone, thereby denying themselves assistance in the event of an overdose. An evaluation of peer based education on these issues is currently being conducted in South Australia. Recent proposals to establish safe injecting rooms in locations where street injection is common may also be worth serious consideration as a way of reducing overdose deaths caused by these risky practices.

4. Encouraging Witnesses of Opioid Overdose to Seek Medical Assistance. A further priority must be to improve users' responses to the overdoses of peers. A number of studies have shown that, in the majority of overdoses, other people are present, but may delay seeking assistance due to fear of police action (Darke et al, 1996a; 1996b; Zador et al, 1996). For example, Zador et al (1996), who examined the circumstances surrounding 152 fatal overdoses in New South Wales, reported that medical assistance was sought prior to death in only 10% of cases. A further study by Darke et al (1996b), who interviewed a large sample of injecting drug users, revealed that many who had been present at the overdose of a friend reported either delaying or failing to seek medical assistance. By far the most commonly cited reason for delay in seeking medical assistance was fear of police involvement Current initiatives throughout Australia to limit police attendance at overdoses may go some way to reducing these concerns, thereby encouraging earlier requests for medical assistance.

A further strategy to reduce the overdose toll may be to teach injecting drug users effective resuscitation techniques. One component of such education may include the distribution of naloxone, which is discussed below.

5. The Distribution of Naloxone. Naloxone is a narcotic antagonist that rapidly reverses the effects of acute narcosis, including respiratory depression, sedation and hypotension. It is routinely used by ambulance and emergency department staff to reverse the effects of opioid overdose. Distributing or selling naloxone over the counter to high risk heroin users has been proposed as one means of reducing the number of fatalities due to opioid overdose (Darke & Hall, 1997; Strang et al, 1996). There are a number of reasons for presupposing that the distribution of naloxone may be an effective strategy for reducing the rate of fatal opioid overdose. Firstly, as discussed above, there are often many witnesses to an overdose but they frequently delay or avoid seeking medical assistance. They would, however, be in a position to administer naloxone if it was available. Secondly, research has indicated both that immediate death from overdose is rare, meaning that there is ample opportunity for

bystanders to intervene and secondly, that the majority of fatal overdoses occur in the home of a victim or that of another user (Zador et al, 1996). Thus, if heroin users were encouraged to maintain a supply of naloxone in their own homes, it could be used in the majority of overdose instances.

There are also, however, a number of potential problems with the distribution of naloxone. These include the fact that naloxone is only available on prescription and can only be administered by a medical practitioner or licensed paramedic. Thus, it would need to be rescheduled. Another concern centres on the relatively short half-life of naloxone, particularly in comparison to heroin. A person who has overdosed on heroin may recover upon administration of naloxone only to overdose again after the effects of the naloxone have worn off. This potential problem could be overcome by educating users about the risks of further overdoses and by providing them with multiple doses of naloxone.

In summary, as there are a number of potential liabilities to the distribution of naloxone, the extent to which any benefits of naloxone distribution are outweighed by these costs needs to be determined through a carefully planned trial and evaluation.

4.3. Concluding Comments.

The results of this and other research make it apparent that opioid overdose is a major public health issue. Among young Australian adults it is one of the leading causes of death. Until recently, relatively little attention has been paid to this issue and few resources have been devoted to reducing the rate of overdose. This imbalance between the high rate of opioid overdose and the sparse resources devoted to its prevention needs to be addressed.

REFERENCES

Aderjan, R., Hoemann, S., Schmitt, G. & Skopp, G. (1995). Morphine and morphine glucuronides in serum of heroin consumers and in heroin-related deaths determined by HPLC with native fluorescence detection. *Journal of Analytical Toxicology*, **19**, 163-168.

Australian Bureau of Criminal Intelligence (1997). *Australian Illicit Drug report 1996-97*. Canberra: Australian Bureau of Criminal Intelligence.

Baume, P. (1997). *Epidemiologic overview of suicide in Australia*. Paper presented at the Youth Suicide Research Agenda Workshop. Canberra: National Health and Medical Research Council.

Caplehorn, J. R. M., Dalton, S. Y. N., Cluff, M. C., & Petrenas, A. M. (1994) Retention in methadone maintenance and heroin addicts' risk of death. *Addiction,* **89,** 203-207.

Chan, L. T. F., Prolov, T., & Verma, S. C. C. (1988). *Morphine tissue concentrations in fatal cases in New South Wales, 1986-1987*. Paper presented at the 9th Australian and New Zealand Forensic Society Symposium. Brisbane.

Darke, S., & Hall, W. (1997). The distribution of naloxone to heroin users. *Addiction*, **92**, 1195-1199.

Darke, S., Hall, W., Weatherburn, D., & Lind, B. (submitted). Fluctuations in heroin purity and the incidence of fatal heroin overdose. *Addiction*

Darke, S., & Zador, D. (1996). Fatal heroin overdose: A review. *Addiction*, **91**, 1757-1764.

Darke, S., Ross, J. & Hall, W. (1996a). Overdose among heroin users in Sydney, Australia: I. Prevalence and correlates of non-fatal overdose. *Addiction*, **91**, 405-411.

Darke, S., Ross, J. & Hall, W. (1996b). Overdose among heroin users in Sydney, Australia: II. Responses to overdose. *Addiction*, **91**, 413-417.

Davoli, M., Perucci, C. A., Rapiti, E., Bargagli, A. M., D'Ippoliti, D., Forastiere, F., & Abeni, D. (1997). Persistent rise of mortality of injecting drug users in Rome. *American Journal of Public Health*, **87**, 851-853.

de la Fuente, L., Barrio, G., Vicente, J., Bravo, M. J., & Santacreu, J. (1995). The impact of drug related deaths on mortality among young adults in Madrid. *American Journal of Public Health*, **85**, 102-105.

English, D. R., Holman, C. D. J., Milne, E., Winter, M. G., Hulse, G. K., Codde, J. P., Bower, C. I., Corti, B., Dawes, V., de Klerk, N., Knuiman, M. W., Kurinczuk, J. J., Lewin, G. F., & Ryan, G. A. (1995). *The quantification of drug caused morbidity and mortality in Australia, 1995 Edition*. Canberra: Commonwealth Department of Human Services and Health.

Farrell, M., Neeleman, J., Griffiths, P. & Strang, J. (1996). Suicide and overdose among opiate addicts. *Addiction*, **91**, 321-323.

Fugelstad, A. (1994). *Heroin deaths in Stockholm, 1986-1991*, Paper presented to the Fifth International Conference on the Reduction of Drug Related Harm, Toronto.

Gearing, F. R., & Schweitzer, M. D. (1974). An epidemiologic evaluation of long-term methadone maintenance treatment for heroin addiction. *American Journal of Epidemiology*, **100**, 101-112.

Goldberger, B.A., Cone, E.J., Grant, T.M., Caplan, Y.H., Levine, B.S. & Smialek, J.E. (1994) Disposition of heroin and its metabolites in heroin-related deaths. *Journal of Analytical Toxicology*, **18**, 22-28.

Guttierrez-Cebollada, J., de la Torre, R., Ortuno, J., Garces, J. & Cami, J. (1994) Psychotropic drug consumption and other factors associated with heroin overdose. *Drug and Alcohol Dependence*, **35**, 169-174.

Hall, W. (1996). Methadone maintenance treatment as a crime control measure. *Contemporary Issues in Crime and Justice*, **29**, 1-12

Hall, W., & Darke, S. (1997). *Trends in opiate overdose in Australia 1979-1995*. National Drug and Alcohol Research Centre Technical Report 49. Sydney: National Drug and Alcohol Research Centre.

Hando, J., O'Brien, S., Darke, S., Maher, L., & Hall, W. (1997). *The Illicit Drug Reporting System (IDRS) trial: final report*. National Drug and Alcohol Research Centre Monograph No. 31. Sydney: National Drug and Alcohol Research Centre.

Lynskey, M. T., & Hall, W. (submitted). Cohort trends in age of initiation to heroin use. *Drug and Alcohol Review*.

Manning, F.J. & Ingraham, L.H. (1983). Drug "overdoses" among U.S. soldiers in Europe, 1978-1979. I. Demographics and toxicology. *International Journal of the Addictions*, **18**, 89-98.

Mattick, R. P., Oliphant, D., Ward, J., & Hall, W. (1998). The effectiveness of other opioid replacement therapies: LAAM, heroin, buprenorphine, naltrexone and injectable maintenance. In J. Ward, R. Mattick & W. Hall (Eds.), *Methadone maintenance treatment and other opioid replacement therapies* (pp. 123-157). Amsterdam: Harwood Academic Publishers.

Monforte, J.R. (1977). Some observations concerning blood morphine concentrations in narcotic addicts. *Journal of Forensic Sciences*, **22**, 718-724.

Neeleman, J., & Farrell, M. (1997). Fatal methadone and heroin overdoses: Time trends in England and Wales. *Journal of Epidemiology and Community Health*, **51**, 435-437.

Richards, R. G., Reed, D., & Cravey, R. H. (1976). Death from intravenously administered narcotics: a study of 114 cases. *Journal of Forensic Sciences*, **21**, 467-482.

Risser, D., & Schneider, B. (1994). Drug-related deaths between 1985 and 1992 examined at the Institute of Forensic Medicine in Vienna, Austria. *Addiction*, **89**, 851-858.

Ruttenber, A.J. & Luke, J.L. (1984). Heroin-related deaths: new epidemiologic insights. *Science*, **226**, 14-20.

Ruttenber, A.J., Kalter H.O. & Santinga, P. (1990). The role of ethanol abuse in the etiology of heroin-related death. *Journal for Forensic Sciences*, **35**: 891-900.

Sanchez, J., Rodriguez, B., de la Fuente, L., Barrio, G., Vicente, J., Roca, J., Royuela, L., and the State Information System on Drug Abuse (SEIT) Working Group (1995). Opiates or cocaine: mortality from acute reactions in six major Spanish cities. *Journal of Epidemiology and Community Health*, **49**, 54-60.

Steentoft, A., Teige, B., Holmgren, P., Vuori, E., Kristinsson, J., Kaa, E., Wethe, G., Ceder, G., Pikkarainen, J., & Simonsen, K. W. (1996). Fatal poisonings in young drug addicts in the Nordic countries: a comparison between 1984-1985 and 1991. *Forensic Science International*, **78**, 29-37.

Strang, J., Darke, S., Hall, W., Farrell, M. & Ali, R. (1996). Heroin overdose: the case for take-home naloxone. *British Medical Journal*, **312**, 1435.

United States Department of Health and Human Services (1997). Drug Abuse Warning Network Annual Medical Examiner Data 1995. Rockville, MD: United States Department of Health and Human Services.

Walsh, R. A. (1991). Opioid drug accidental deaths in the Newcastle area of New South Wales, 1970-1987. *Drug and Alcohol Review*, **10**, 79-83.

Zador, D., Sunjic, S. & Darke, S. (1996). Heroin-related deaths in New South Wales, 1992: Toxicological findings and circumstances. *Medical Journal of Australia*, **164**, 204-207.

APPENDIX: Statistical Analyses

A.1. Jurisdictional Differences in Rates of Overdose Death

Multiple logistic regression analyses were conducted to predict the odds of dying of an opioid overdose from: year (entered as a linear term) and jurisdiction (entered as eight categories representing each of the eight States and Territories). An interaction term between year and jurisdiction was also included in the model to assess whether there were differences between the jurisdictions in the rate of increase of opioid overdoses over the period.

These analyses indicated that:

1. There was a significant effect of year (OR = 1.08; CI = 1.06 - 1.09) indicating that the rate of fatal opioid overdose increased during the period from 1988 to 1996.

2. There was a significant effect of jurisdiction (OR = .79; CI = .77 - .81) indicating that the rate of opioid overdose varied between the eight States and Territories with New South Wales having the highest rate of opioid overdose throughout the nine year period of the study.

Further analyses indicated that it was not possible to fit a model to the data which included an interaction term between year and jurisdiction as the addition of such a term introduced severe pathologies to the model. Nonetheless, the data in Table 2 presents some evidence to suggest that the rate of increase in some of the less populous States may have been greater than the rate of increase in fatal opioid overdose in New South Wales and Victoria. To provide a preliminary examination of this issue a models of the form described above were fitted separately to the data from each of the eight States and the results of this analysis are summarised in Table A.1. The results in this Table lead to the following conclusions:

1. Firstly, there was a significant association between year and rate of opioid overdose in seven of the eight States and Territories, indicating a significant rise in the rate of opioid overdose in these jurisdictions. Although the association between year and rate of opioid overdose was non-significant in the Northern Territory, this was likely to be a function of the low numbers of overdose in this jurisdiction (there was a total of only 12 opioid overdoses in the Northern Territory throughout the nine year period of the study). Nonetheless, there was some evidence of a trend towards an increase in the rate of opioid overdose in the Northern Territory.

2. Additionally, there was evidence to suggest that the rate of increase in opioid overdose mortality has not been constant across jurisdictions. Specifically, the odds ratios linking year to rate of overdose were higher in some of the less populous States and Territories (e.g., South Australia, Western Australia, Australian Capital Territory) than in New South Wales or Victoria and had non-overlapping confidence intervals indicating significant differences between these jurisdictions in the rate of increase of opioid overdose mortality.

Table A.1: Odds ratios (95% Confidence intervals) between year and rate of opioid overdose for each of the eight jurisdictions.

State	Odds Ratio	95% Confidence Interval	P
New South Wales	1.043	1.025-1.062	<.0001
Victoria	1.057	1.030-1.084	<.0001
Queensland	1.138	1.076-1.203	<.0001
South Australia	1.161	1.101-1.224	<.0001
Western Australia	1.236	1.176-1.300	<.0001
Tasmania	1.203	1.033-1.400	<.05
Northern Territory	1.186	0.938-1.500	>.10
Australian Capital Territory	1.435	1.246-1.653	<.0001

A.2. Multiple regression analysis of age at death

A multiple linear regression analysis was conducted on age at death with year and State as the predictor variables. An interaction between state and year was also included in the model. The final model included the variables year and State. Results indicated that age at death was linearly related to the year in which death occurred, increasing by 5 months per year ($\beta = 0.44$, 95% CI = 0.29 - 0.59). These results are broadly consistent with those reported by Hall and Darke (1997) although there are minor differences which can be attributed to a combination of the expanded age range and more restricted time frame used in the current analyses. Additionally, the results of the model indicated no significant association between State/ Territory and mean age at death, indicating that the mean age at death did not vary between jurisdictions. Importantly, the final fitted model did not include an interaction between year and State as initial model fitting indicating that the addition of this term did not significantly improve the fit of the model to the data.

A.3. Logistic regression analysis of opioid overdose rate

Multiple logistic regression analyses were conducted to examine trends in opioid overdose mortality between 1988 and 1996 after adjusting for gender and age-group (entered as four categories: 15-24 years, 25-34 years, 34-44 years and 45-54 years). Year was entered as a linear term.

Results of this analysis indicated a significant association between year and rate of overdose (OR = 1.08, 95% CI = 1.07 - 1.09) indicating an increase in the rate of opioid overdose in recent years.

There was also a significant main effect of gender (OR = 0.26, 95% CI = 0.24 - 0.29) indicating that the rate of opioid overdose was approximately four times greater among males than among females.

There was a significant association between age group (15-24 years, 25-34 years, 34-44 years and 45-54 years) and rate of opioid overdose (OR = 0.74, 95% CI = 0.72-0.76) indicating that the rate of opioid overdose was significantly higher amongst the younger age groups.

Finally, consideration was given to including interaction terms between age group, gender and year in the model to examine the extent to which the increase in rate of overdose mortality over time was constant across gender and age group. However, inclusion of these interaction terms introduced severe pathologies into the model, due to the low rate of overdose mortality amongst older age groups.

A.4. Logistic regression analysis of proportion of deaths.

Multiple logistic regression analyses were conducted to examine differences in trends in the proportion of deaths amongst men and women attributed to opioid during the interval from 1988 to 1996. As in the previous analyses, year was entered as a linear term and an interaction term between year and sex was tested for inclusion in the model. The results of this analysis lead to the following conclusions:

There was a significant effect for gender (OR = 0.52, CI = 0.48 - 0.57) indicating that the proportion of deaths attributed to opioid overdose was greater among males than among females.

There was a significant effect for year (OR = 1.10, CI = 1.08 - 1.11) indicating that the proportion of deaths attributed to opioid overdose has increased during the period from 1988 to 1996.

A.5. Logistic regression analysis of proportion of deaths by age group.

Multiple logistic regression analyses were conducted to examine differences in trends in the proportion of deaths attributed to opioid during the interval from 1988 to 1996 for each of four age groups (15-24 years; 25-34 years; 35-44 years; 45-54 years). As in the previous analyses, year was entered as a linear term and an interaction term between year and age was tested for inclusion in the model. The results of this analysis lead to the following conclusions:

There was a significant effect for year (OR = 1.07, CI = 1.04 - 1.10) indicating that the proportion of deaths attributed to opioid overdose has increased during the period from 1988 to 1996.

There was a significant effect for age (OR = 0.10, CI = 0.03 - 0.30) indicating that the proportion of deaths attributed to opioid overdose varied by age. Specifically, the highest proportions of deaths attributed to opioid overdose were among those aged 25-34 years while the lowest proportion of deaths attributed to opioid overdose was among those aged 45-54 years.

Again, exploratory analyses indicated that the addition of an interaction term between age group and year introduced severe pathologies to the model. Thus to examine the extent to which the rate of increase in the proportion of deaths may have varied by age group a series of models was fitted to the data to calculate the association between year (1988-1996) and proportion of deaths attributed to opioid overdose for each of the separate four age groups (15-24 years; 25-34 years; 35-44 years and 45-54 years). The results of this analysis are summarised in Table A.5 and lead to the following conclusions:

1. Firstly, there was a significant increase in the proportion of deaths attributed to opioid overdose in each of the four age groups.

2. Secondly, there was evidence to suggest that the proportion of deaths attributed to opioid overdose has increased more markedly in the older age groups (34-44 and 45-years) than in the younger age groups (15-24 years and 25-34 years). Specifically, the odds ratios linking year to proportion of deaths attributed to opioid overdose for these two sets of ages had non-overlapping confidence intervals.

Table A.5: Odds ratios (95% Confidence intervals) between age group and proportion of deaths attributed to opioid overdose.

Age Group	Odds Ratio	95% Confidence Interval	P
15-24 years	1.092	1.064-1.121	<.0001
25-34 years	1.071	1.051-1.092	<.0001
35-44 years	1.186	1.152-1.222	<.0001

45-54 years	1.330	1.230-1.438	<.0001