DRUG POLICY MODELLING PROJECT

MONOGRAPH 03

ESTIMATING THE PREVALENCE OF PROBLEMATIC HEROIN USE IN MELBOURNE

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December 2005

Drug Policy Modelling Project Monograph Series

The Drug Policy Modelling Project Monograph Series was funded by Colonial Foundation Trust.

Published by Turning Point Alcohol and Drug Centre Inc.

December 2005

ISBN: 1 74001 164 3

The correct citation for this publication is: Dietze, P., Hickman, M. & Kimber, J. (2005). Monograph No. 03: Estimating the prevalence of problematic heroin use in Melbourne. *DPMP Monograph Series*. Fitzroy: Turning Point Alcohol and Drug Centre.

THE DRUG POLICY MODELLING PROJECT

This monograph forms part of the Drug Policy Modelling Project (DPMP) Monograph Series.

Drugs are a major social problem and are inextricably linked to the major socio-economic issues of our time. Our current drug policies are inadequate and governments are not getting the best returns on their investment. There are a number of reasons why: there is a lack of evidence upon which to base policies; the evidence that does exist is not necessarily analysed and used in policy decision-making; we do not have adequate approaches or models to help policy-makers make good decisions about dealing with drug problems; and drug policy is a highly complicated and politicised arena.

The aim of the Drug Policy Modelling Project (DPMP) is to create valuable new drug policy insights, ideas and interventions that will allow Australia to respond with alacrity and success to illicit drug use. DPMP addresses drug policy using a comprehensive approach, that includes consideration of law enforcement, prevention, treatment and harm reduction. The dynamic interaction between policy options is an essential component in understanding best investment in drug policy. Stage One has: a) produced new insights into heroin use, harms, and the economics of drug markets; b) identified what we know about what works (through systematic reviews); c) identified valuable dynamic modelling approaches to underpin decision support tools; and d) mapped out the national policy-making process in a new way, as a prelude to gaining new understanding of policy-making processes and building highly effective research-policy interaction.

This monograph (No. 03) reports on work that tested new methods for estimating the prevalence of problematic heroin use in Melbourne. Using the non-fatal heroin overdose data, three different capture-recapture methods were employed. Estimates were derived for the year 2000 and the year 2003/2004. The lack of plausibility of some estimates coupled with the poor 'goodness-of-fit' of some models points to the need to continue to develop new methods for estimating problematic heroin use.

Monographs in the series are:

01. What is Australia's "drug budget"? The policy mix of illicit drug-related government spending in Australia
02. Drug policy interventions: A comprehensive list and a review of classification schemes
03. Estimating the prevalence of problematic heroin use in Melbourne
04. Australian illicit drugs policy: Mapping structures and processes
05. Drug law enforcement: the evidence
06. A systematic review of harm reduction
07. School based drug prevention: A systematic review of the effectiveness on illicit drug use
08. A review of approaches to studying illicit drug markets

09. Heroin markets in Australia: Current understandings and future possibilities
10. Data sources on illicit drug use and harm in Australia
11. SimDrug: Exploring the complexity of heroin use in Melbourne
12. Popular culture and the prevention of illicit drug use: A pilot study of popular music and the acceptability of drugs
13. Scoping the potential uses of systems thinking in developing policy on illicit drugs

DPMP strives to generate new policies, new ways of making policy and new policy activity and evaluation. Ultimately our program of work aims to generate effective new illicit drug policy in Australia. I hope this Monograph contributes to Australian drug policy and that you find it informative and useful.

Alison Ritter
Director, DPMP

ACKNOWLEDGEMENTS

The authors wish to thank the Premier's Drug Prevention Council and the Colonial Foundation Trust for providing funding for the work detailed in this report. In particular we would like to thank Diane Edwards for her support throughout the duration of the project. We would also like to thank Stefan Cvetkovski and Paul McElwee from Turning Point Alcohol and Drug Centre, and the Melbourne Metropolitan Ambulance Service, for their help in the provision of data as well as advice on data analysis.

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EXECUTIVE SUMMARY

Estimating the prevalence of drug use is one of the key focal areas of alcohol and drug epidemiology. Estimation of the extent of alcohol and drug use in the Australian community has primarily been undertaken using surveys of the general population. Nevertheless, it is widely understood that prevalence estimates derived from general population surveys underestimate the true extent of drug use in the community for drugs of low use prevalence (eg. heroin) because of issues around sampling (eg. response rates and the extent to which crucial samples such as the homeless are missed in household surveys) and the truthfulness of responses to questions concerning illegal or hidden behaviours. In response, epidemiologists have applied specialised statistical techniques to the analysis of data sources on the extent of drug-related harm (eg. opioid overdose deaths) to produce estimates of the extent of problematic drug use in the Australian community.

Prevalence estimation using secondary data sources has generally been undertaken only in relation to heroin use in Australia. This work has used a variety of techniques (eg. capture-recapture, back-projection, multiplier) in accordance with a general consensus that has emerged around the application of such techniques to the estimation of problematic drug use. In applying these methods Australian work has developed multiple estimates using available statistical estimation tools with convergence among estimates used as the source of the most parsimonious estimate (eg. the median of the estimates derived). While this approach is appealing, the resultant 'best' estimates are derived primarily from the application of simple mortality multipliers (eg. 1% annual mortality rate for heroin users) to the number of opioid overdose deaths occurring in specific Australian jurisdictions (generally NSW). The problem of this multiplier approach is highlighted by the effect of the heroin shortage in Australia.

The aim of this component of the DPMP was to develop plausible estimates of the prevalence of heroin use in Melbourne with a view to informing various elements of DPMP projects. The work was also designed to provide a method for estimating the extent of injecting drug use more widely (specifically through application to amphetamines). It was funded in part by a Travelling Scholarship from the Victorian Premier's Drug Prevention Council awarded to Paul Dietze.

Approach

There are few estimates of the prevalence of problematic drug use available for Victoria in which Victorian-specific data sources have been used. Indeed, recent estimates of the prevalence of problematic heroin use for Victoria derive almost exclusively from analysis of data available in New South Wales. The data chosen for this exercise were ambulance attendances at drug-related events in Melbourne as they are a unique source of information on drug-related harm available to the project team that have not been extensively used in previous prevalence estimation exercises. In this context the aim of the work was to examine their potential for use in prevalence estimation exercises. The characteristics of the database mean that they can be used for estimating the prevalence of not only heroin use but also the prevalence of the use of a variety of other drugs.

Capture-recapture estimation was undertaken using available unique identifiers for cases. Three main methods were employed, two of which involved assuming that the population under investigation was closed (ie. that there is no migration in or out of the population) and one assuming an open population (allowing for migration). The closed population estimates were

generated through truncated Poisson and Poisson regression modelling and the open population estimates were generated through the application of a Jolly-Seber type model.

Key findings

A number of different methods and models were tested. The best estimates (for the years 2000 and 2003/04) to date derived from the project for Melbourne are displayed in the table below.

Table 1: Estimates of the prevalence of problematic heroin use in Melbourne, 2000 and 2003/04 *(95% CIs)*

Year	Stratum	Truncated Poisson estimate	Poisson regression "best" model	Poisson regression "independent" model
2000	15-24M	4180 *(3315-5657)*	21646 *(10606-45135)*	6306 *(4714-8547)*
	15-24F	1801 *(1377-2604)*	5009 *(2528-10367)*	2904 *(1907-4557)*
	25-64M	6977 *(5860-8619)*	39872 *(17210-94862)*	9849 *(7867-12431)*
	25-64F	2094 *(1568-3153)*	7228 *(3171-17214)*	4487 *(2641-7851)*
	Unstratified	15026 *(13311-17428)*	50450 *(37323-68586)*	21475 *(15542-22152)*
2003/04	15-24M	1192 *(894-1787)*	7698 *(1299-54185)*	1747 *(1136-2790)*
	15-24F	824 *(494-2499)*	2349 *(442-16458)*	543 *(365-865)*
	25-64M	3892 *(3172-5034)*	6453 *(3764-11583)*	3805 *(3074-4772)*
	25-64F	1230 *(911-1892)*	1254 *(806-2081)*	1458 *(991-2229)*
	Unstratified	7089 *(6103-8457)*	11541 *(7851-17373)*	7148 *(6102-8432)*

Implications

The results of this study have shown that ambulance data can be used to generate estimates of the prevalence of heroin use in Melbourne using closed population capture-recapture techniques. Nevertheless, there were significant problems with the estimates that were generated. Some appeared to be implausibly low, others of limited precision and the most theoretical parsimonious models provided only poor fit for the data. In all, the findings of this component of the study suggest that the techniques, as implemented, do not provide reasonable estimates of the prevalence of heroin use in Melbourne and are even more unsuited to the examination of some other drugs such as amphetamines.

One problem with the work that was undertaken was its excessive reliance on one data source. While this approach has been used in other studies, many studies of the prevalence of heroin use examine repeated captures *across* multiple data sources rather than multiple captures within a single data source. Future work in Melbourne should concentrate on developing data sources with compatible identifiers so that capture-recapture studies can be undertaken across the large variety of data that is currently collected on heroin-related harms in Melbourne.

INTRODUCTION AND BACKGROUND

Estimating the prevalence of alcohol and drug use is one of the key focal areas of alcohol and drug epidemiology. Estimation of the extent of alcohol and drug use in the Australian community has primarily been undertaken using surveys of the general population.[1] Nevertheless, it is widely understood that prevalence estimates derived from general population surveys underestimate the true extent of drug use in the community for drugs of low use prevalence (eg heroin) because of issues around sampling (eg response rates and the extent to which crucial samples such as the homeless are missed in household surveys) and the truthfulness of responses to questions concerning illegal or hidden behaviours.[2] In response, epidemiologists have applied specialised statistical techniques to the analysis of data sources on the extent of drug related harm (eg opioid overdose deaths) to produce estimates of the extent of problematic drug use in the Australian community.[3 4]

Prevalence estimation using secondary data sources has generally been undertaken only in relation to heroin use in Australia.[3 5] This work has used a variety of techniques (eg capture-recapture, back-projection, multiplier) in accordance with a general consensus that has emerged around the application of such techniques to the estimation of problematic drug use.[6-8] In applying these methods Australian work has developed multiple estimates using available statistical estimation tools with convergence among estimates used as the source of the most parsimonious estimate (eg the median of the estimates derived[3]). While this approach is appealing, the resultant 'best' estimates are derived primarily from the application of simple mortality multipliers (eg 1% annual mortality rate for heroin users) to the number of opioid overdose deaths occurring in specific Australian jurisdictions (generally NSW).[3-5] The problem of this multiplier approach is highlighted by the effect of the heroin shortage in Australia.[9] In spite of the major changes in risk for opioid overdose associated with a change in heroin supply researchers have applied the same mortality multiplier to the number of opioid overdose deaths producing estimates of the number of problematic heroin users (in this case termed 'current regular' heroin users) that showed a dramatic decline following the onset of the shortage.[5] However, in the context of a change in risk of death associated with the shortage it is unlikely that the mortality multiplier should be allowed to remain stable. In order to generate more parsimonious estimates of the number of at-risk heroin users, estimates should only be derived using statistical techniques that can accommodate the dynamics of drug market conditions. One such technique is capture-recapture.

Capture-recapture techniques have now been widely used in generating estimates of the prevalence of problematic drug use.[10] Based on techniques developed in estimating the size of animal populations,[11] these rely on an examination of the degree to which individuals appear on multiple occasions within specific data sources or across different data sources. Simple application of log-linear modelling techniques on the extent of capture within or between data sources allows for the calculation of the size of the population that is not captured. From this calculation the overall size of the population of interest can be determined. In the drugs field, estimates of the size of the drug using population of interest have been generated both from multiple capture rates within specific data sources,[3] as well as between data sources.[4]

There are few estimates of the prevalence of problematic drug use available for Victoria in which Victoria-specific data sources have been used. Indeed, recent estimates of the prevalence of problematic heroin use for Victoria derive almost exclusively from analysis of data available in New South Wales.[5] Nevertheless, data on ambulance attendance at drug related events in

Melbourne, collected and compiled in Victoria by Turning Point Alcohol and Drug Centre, has the potential to provide estimates of problematic or at-risk drug use specific for Victoria. These data have not been extensively used in previous prevalence estimation exercises.

The Turning Point Alcohol and Drug Centre/Metropolitan Ambulance Service database on drug-related ambulance attendances was established with a focus on heroin overdoses in 1997. From June 1998 the database was extended to encompass all drug-related ambulance attendances meaning that data on a variety of different drug classes (eg alcohol, benzodiazepines, 'party' drugs, inhalants) has been available since that time. In this way the database is unique in that, to our knowledge, no other comparable data are collected anywhere else in the world. Importantly, the database contains a unique identifier (completed for the majority of cases) that allows for the examination of repeated capture within the database over time. Further, as the database contains basic descriptive details of case, patterns and trends in the data can be examined over different geographic locations within Melbourne and patient characteristics can also be examined.

AIMS

The key aims of this component of the DPMP were to:

1. Estimate the size of the 'at-risk' heroin using population both before and after the onset of the heroin shortage

2. Estimate the prevalence of the size of 'at-risk' populations according to drug classes

Significant work of this nature has previously been undertaken at the Centre for Research on Drugs and Health Behaviour at Imperial College by Matthew Hickman and colleagues.[10] In order to achieve the aims listed above a short study tour of the UK, primarily involving work at Imperial College, was organised that was funded by a Premier's Drug Prevention Council Travelling Scholarship. The primary objective of the study tour program was to undertake work using ambulance data to examine the characteristics of problematic drug use in Melbourne captured on this dataset and examine its utility in wider prevalence estimation.

METHOD

Data source

Prior to 1997 there was no established systematic data collection on ambulance attendances at drug related events in Melbourne. There was a clear need for the collection of such data in the context of claims of escalating heroin use and related harms and evidence from other jurisdictions of the utility of ambulance data for surveillance purposes.[12] In late 1997 Turning Point Alcohol and Drug Centre and the Melbourne Metropolitan Ambulance Service (MAS) commenced a collaborative project to establish a database on ambulance attendances at heroin overdoses in Melbourne. This involved the selection of heroin-involved Patient Care Records (PCRs), completed by ambulance paramedics at the time of attendance, and compilation of key variables on a Microsoft Access database by trained data coders. Key variables extracted from the PCRs and entered onto the database included: patient age and sex, time and location of attendance, recorded naloxone administration, police attendance and transportation outcome.[13] The value of the compilation was quickly evident with the reports emanating from the project soon becoming one of the key surveillance indicators on heroin related harms in Melbourne. Recognition of this functionality led to the expansion of the database such that from June 1998 data on ambulance attendances at events related to drugs other than heroin were also compiled. Additional data extracted from PCRs have also been included on the database as data collection has been proceeding. For example, coded unique identifiers for cases, involving a combination of letters from first names and surnames as well as year of birth, have been included from 1999 onwards in order to identify multiple drug-related presentations to paramedics among individuals.

The database used for the work program undertaken in the UK included records from June 1998 – April 2004; in total over 67,000 records.

Procedure

Capture-recapture estimation was undertaken using available unique identifiers for attendances, as detailed above. Three main methods were employed, two of which involved assuming that the population under investigation was closed (ie. that there is no migration in or out of the population) and one assuming an open population (allowing for migration). The closed population estimates were generated through truncated Poisson and Poisson regression modelling and the open population estimates were generated through the application of a Jolly-Seber type model. Truncated Poisson estimates of the prevalence of heroin use in Melbourne were undertaken using Zelterman's (1988) approach in which only two capture histories are used. Zelterman's equations were implemented in MS excel. Poisson regression was undertaken using STATA with three 4-month periods providing samples for each of the two years under consideration (eg Jan-Apr, May-Aug, Sep-Dec for 2000), resulting in 3-sample capture-recapture estimation. The Jolly-Seber model was parameterised through the POPAN (POPulation ANalysis) procedure available in Program MARK[14], specialised software developed for prevalence estimation, which allows for the generation of estimates of the number of drug users as well as new recruits (ie. migration into the population). This implementation required the use of monthly periods for each of the two years examined. In all estimations cases were stratified according to age (15-24, 25-64) and sex (M, F).

An initial examination of the feasibility of applying the prevalence estimation techniques described above was undertaken using heroin overdose cases only and this produced implausibly low estimates. As a result, heroin overdose attendances were combined with 'likely heroin involvement' attendances in order to increase the number of cases and the potential for multiple capture. In order to investigate the size of the heroin using population before and after the shortage, two periods were chosen (on the basis of data suitability) – the 2000 calendar year and May 2003 – April 2004.

RESULTS

Truncated Poisson estimates

Truncated Poisson estimates of the prevalence of heroin use in Melbourne were generated using Zelterman's [15] approach. The estimates generated for the two periods are detailed in Table 2. The estimates generated through this approach appear implausibly low. For example, if the estimate generated for 2000 were correct, it would suggest that the rate of heroin related mortality was around 2.5% (around 300 deaths recorded), much higher than that generally found in studies of heroin users, typically around 1-1.25%. [5]

Table 2: Truncated Poisson estimates of the prevalence of heroin use in Melbourne, 2000 & 2003/04

Year	Stratum	Lower 95% CI	Estimate	Upper 95% CI
2000	15-24M	3315	4180	5657
	15-24F	1377	1801	2604
	25-64M	5860	6977	8619
	25-64F	1568	2094	3153
	Total	13311	15026	17248
2003/04	15-24M	894	1192	1787
	15-24F	494	824	2499
	25-64M	3172	3892	5034
	25-64F	911	1230	1892
	Total	6103	7089	8457

Log-linear models

Poisson regression was used to generate log-linear models to fit the amount of overlap between periods of heroin-involved cases. Table 3 shows the amount of overlap across periods for the 2000 calendar year. This Table also shows the cell to be estimated (ie. those not captured in any of the three periods) through the log-linear modelling techniques used.

Table 3: Overlap across chosen 4-month periods for 3-sample capture-recapture estimation using log-linear modelling of heroin use in Melbourne, 2000

		Period 3 (Sep-Dec)			
		Present		Absent	
		Period 2 (May-Aug)			
		Present	Absent	Present	Absent
Period 1 (Jan-Apr)	Present	4	100	19	988
	Absent	16	970	823	*

The poisson regression undertaken included estimation using a variety of models allowing for interactions (in this case serial dependencies) across the chosen four-month periods, along with an independent (ie. no dependencies) and a fully saturated model. Within each stratum models were chosen on the basis of their fit of the data (through G^2, the maximum likelihood ratio,

where a non-significant value implies a good fit or the smallest Aikake Information Criterion, AIC). The estimates generated for the two periods are detailed in Table 4 according to the best fitting model. All of these models fitted well yet produced estimates of low precision as indicated by the width of the confidence intervals presented. Comparison between the two years suggests a very large (perhaps implausible) fall in the number of heroin users between the two periods considered.

Table 4: Log-linear 'best' model estimates of the prevalence of heroin use in Melbourne, 2000 & 2003/04

		Best model			
2000	**Lower 95% CI**	**Estimate**	**Upper 95% CI**	**G^2**	***p***
Unstratified	37323	50450	68586	1.534	0.464
15-24 M	10606	21646	45135	1.731	0.421
15-24 F	2528	5009	10367	0.404	0.525
25-64 M	17210	39872	94862	0.526	0.468
25-64 F	3171	7228	17214	0.166	0.683
2003/04					
Unstratified	7851	11541	17373	3.482	0.062
15-24 M	1299	7698	54185	2.917	0.088
15-24 F	442	2349	16458	1.449	0.229
25-64 M	3764	6453	11583	0.385	0.535
25-64 F*	806	1254	2081	0.824	0.662

While the best fitting models detailed in Table 4 showed reasonable fit of the data, there is little theoretical basis for assuming any interactions between the periods used within the years. In this regard there is no evidence of consistent seasonality in heroin overdose numbers in Melbourne and there appears to be no reason why there should be interactions of the sort modelled. As a consequence the most parsimonious model is the independent model which assumes no interactions between the periods within the two years considered. Table 5 details the results of the independent models for each stratum for the two years examined. The estimates generated are considerably more conservative than those generated through the "best" models shown in Table 4. However, the model fit for the independent models was poor and the precision of the estimates remained low.

Table 5: Log-linear 'independent' model estimates of the prevalence of heroin use in Melbourne, 2000 & 2003/04

	Independent model				
2000	**Lower 95% CI**	**estimate**	**Upper 95% CI**	**G^2**	***p***
Unstratified	15542	21475	22152	98.319	0.000
15-24 M	4714	6306	8547	40.029	0.000
15-24 F	1907	2904	4557	8.340	0.015
25-64 M	7867	9849	12431	47.740	0.000
25-64 F	2641	4487	7851	4.055	0.132
2003/04					
Unstratified	6102	7148	8432	14.653	0.002
15-24 M	1136	1747	2790	9.042	0.029
15-24 F	365	543	865	9.713	0.021
25-64 M	3074	3805	4772	6.529	0.089
25-64 F*	991	1458	2229	1.763	0.623

Jolly-Seber models

Attempts to develop estimates of the prevalence of heroin use in Melbourne using the POPAN procedure implemented in Program MARK proved unsuccessful. The outputs indicated implausible levels of migration (around 1800 per month) into a small population (around 500) for the unstratified analysis. The reason for this spurious result is that the Jolly-Seber model was unable to provide reasonable estimates from a sample with a relatively small degree of overlap such as that seen in the Melbourne ambulance attendance data. Indeed, the Jolly-Seber model provided the most parsimonious estimate generated from similar analyses undertaken with data from the Sydney Medically Supervised Injecting Centre, where the degree of overlap across capture periods (in this case months) was high.

Additional prevalence estimation work

A preliminary exploration of whether the ambulance attendance dataset could be used to examine the size of the at-risk populations for drugs other than heroin in Melbourne as well as the size of the at-risk heroin using population within specific areas of the city was also undertaken. Initial examination of the data suggested that the number of repeat multiple captures within either year under examination was so low as to preclude analysis for classes of illicit drugs other than heroin, especially in light of the problems found with the heroin cases above. The issues evident in relation to the heroin cases for the whole of Melbourne also precluded further analysis within specific areas of the city.

DISCUSSION

This study aimed to generate a series of estimates of the prevalence of heroin and other drug use in Melbourne using statistical modelling of one trends in ambulance attendance data. In all, the findings of this study suggest that the statistical techniques, as implemented, do not provide reasonable estimates of the prevalence of heroin use in Melbourne and are even more unsuited to the examination of some other drugs such as amphetamines. This is because there were significant problems with the estimates that were generated in relation to the prevalence of heroin use. The truncated Poisson estimates appeared to be implausibly low. The estimates generated through the 3-sample capture-recapture modelling were of limited precision and the most theoretical parsimonious models provided only poor fit for the data. This was most likely a result of the limited number of recaptures observed within the years examined in Melbourne – a problem that precluded sensible modelling using Jolly-Seber type approaches. These issues are even more problematic for estimation in relation to drugs other than heroin as a preliminary examination showed the extent of overlap (recapture) for these drugs was even lower than that found for heroin.

Implications

One problem with the work that was undertaken was its excessive reliance on one data source. While this approach has been used in other studies, many studies of the prevalence of heroin use examine repeated captures *across* multiple data sources rather than multiple captures within a single data source. To this effect the feasibility of developing:

- compatible identifiers across datasets, and
- protocols for data sharing and management that are consistent with privacy principles and ethics guidelines

in Melbourne should be examined so that capture-recapture studies can be undertaken across the large variety of data that is currently collected on heroin and other drug related harms in Melbourne. Such a task will involve law enforcement, health and other data custodians, but should be capable of providing more reliable and precise estimates of the extent of problematic drug use in the city.

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