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# How do methamphetamine users respond to changes in methamphetamine price?

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*One of the core objectives of supply-side drug law enforcement is to reduce drug use by raising the cost of buying drugs. The effectiveness of this strategy depends on how illicit drug users respond to the rise in costs. The aim of the current study was to estimate how methamphetamine users would respond to changes in the prices of methamphetamine and heroin, using hypothetical drug purchasing scenarios. A sample of 101 people who reported using methamphetamine in the past month was recruited from primary healthcare facilities in Sydney, Wollongong and Newcastle. Participants were given a hypothetical fixed drug budget, presented with a range of drug 'pricelists' and asked how many units of each drug on the pricelist they would buy with their drug budget. The prices of methamphetamine and heroin were varied independently across successive trials and the quantity of each drug purchased at each methamphetamine and heroin price was recorded. Results revealed that methamphetamine purchases decreased significantly as the price of methamphetamine increased (a 10% price increase led to an 18%-19% fall), as did heroin purchases in response to heroin price increases (a 10% price increase led to a 16%-27% fall). Among methamphetamine users, increases in methamphetamine prices produced some substitution into heroin. Additionally, dependent methamphetamine users purchased more pharmaceutical opioids while the non-dependent group purchased more cocaine. Dependent and non-dependent heroin users also responded differently to changes in the price of heroin. Dependent heroin users reacted to increased heroin prices by significantly increasing their purchases of methamphetamine, pharmaceutical opioids and benzodiazepines. At the same time they purchased less cocaine. Non-dependent heroin users responded simply by increasing their purchases of pharmaceutical opioids. In most instances where substitution occurred, the fall in consumption of amphetamine (or heroin) was considerably greater than the increase in consumption of other drugs.*

*KEYWORDS: price elasticity, cross-price elasticity, supply-side drug law enforcement, methamphetamine, ice.*

## INTRODUCTION

Methamphetamine is one of the most commonly used illicit drugs in Australia.[3] The most recent National Drug Strategy Household Survey estimated that more than one million Australians – or 6.3 per cent of the population aged 14 years and older – had used methamphetamine at least once in their lifetime (Australian Institute of Health and Welfare 2008). While this represents a decrease from the 2004 figure of 9.1 per cent, some aggregate markers of methamphetamine-related harm have been increasing in recent years. For example, there have been substantial increases in the number of police-recorded incidents of use/possess amphetamines (Degenhardt et al. 2008; Snowball et al. 2008) and in the number of methamphetamine-related presentations to NSW emergency departments (Snowball et al. 2008).

Perhaps of paramount concern to policy makers is the high level of dependence found among populations of frequent methamphetamine users. Research estimates that there were approximately 28,000 dependent methamphetamine users in NSW and over 72,000 dependent users across Australia in 2003 (McKetin et al. 2005a). Heavy use of methamphetamine is known to result in substantial harms to users, including financial stress, emotional and social problems, physical and mental health problems (Darke et al. 2008; Degenhardt & Topp 2003; McKetin, McLaren & Kelly 2005b; McKetin et al. 2006; Vincent et al. 1998; White, Breen & Degenhardt 2003), risky sexual and injecting behaviours (Darke et al. 2008), as well as posing risks to the wider community through high rates of criminal activity (Degenhardt et al. 2008; McKetin et al. 2005a; 2005b).

Australia's efforts to reduce these harms are underpinned by a policy approach of harm minimisation, which comprises three elements: demand reduction, harm reduction and supply reduction. Demand reduction measures are those that primarily focus on prevention of illicit

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drug use (e.g. school-based education programs) or treatment for dependent users (e.g. cognitive behavioural counselling or pharmacotherapies). Not all demand reduction activities are effective but there is some evidence in support of programs such as school-based drug prevention (e.g. Caulkins et al. 2002). While pharmacotherapies have been well established for heroin dependence for many years, there has typically been much less success in developing such treatments for methamphetamine and other psycho-stimulants. Nevertheless, recent clinical trials have provided some promising signs of progress (e.g. Shearer et al. 2009).

Harm reduction strategies are not intended to reduce drug use per se but instead aim to reduce the harms associated with substance abuse (e.g. needle and syringe programs and supervised injecting facilities are intended to reduce the transmission of blood borne viruses). Again, some harm reduction efforts will be more effective than others but there is certainly evidence that strategies such as needle and syringe programs have been effective in limiting the harms associated with injecting use of illicit drugs such as methamphetamine (Commonwealth Department of Health and Ageing 2002; Hurley, Jolley & Kaldor 1997).

Supply reduction efforts are those that aim to intercept illicit drugs before they get onto the market (e.g. through cross-border interdiction or dismantling domestic drug laboratories). One of the core rationales underpinning supply side law enforcement is that, by increasing the risks associated with trading in illicit drugs, dealers will be forced to increase the price of drugs to compensate themselves for the risks they take. Some economists argue that, like most other commodities, an increase in the price of a drug should reduce consumption of that drug. Reductions in use should, in turn, bring reductions in drug-related harm. The relative efficacy of supply reduction efforts therefore depends critically on the extent to which consumption of illicit drugs responds to changes in drug prices. Economists quantify the consumer reaction to price change in terms of price elasticity of demand. For a particular drug, own-price elasticity of demand measures the change in consumption of that drug as a consequence of variation in its own price. The more consumption falls in response to a price increase, for example, the more elastic is demand. Price elastic demand describes the situation where consumption responds to price changes to the extent that an x per cent increase in price leads to at least an x per cent reduction in consumption. In contrast, price inelastic demand is said to occur when an x per cent price increase results in a less than x per cent reduction in consumption. If demand is price elastic, pushing up the price of an illicit drug will produce a reduction in its use and a reduction in overall expenditure on the drug. If demand is inelastic, pushing up the price of a drug may produce some reduction in its use but overall expenditure on the drug will increase.

The way in which consumption of a drug changes in response to variations in its price is only part of the picture. Methamphetamine users, like most drug users, tend to use a range of substances. Some drugs are used in concert with methamphetamine (i.e. as complement drugs) while others may be used in place of methamphetamine (i.e. as substitute drugs). Consequently, increases in the price of methamphetamine may result in decreased consumption of methamphetamine and some other (complement) drugs but could lead to increases in consumption of other just as harmful (substitute) drugs. A more complete understanding of the effectiveness of an increase in the price of methamphetamine requires knowledge of how consumption of all drugs responds to that price increase. For a particular drug, cross-price elasticity measures the change in consumption of another drug in response to variations in the price of that drug. When the cross-price elasticity is positive the drugs are considered to be substitutes and when it is negative they are considered to be complements.

Economists have tended to estimate the responsiveness of demand for illicit drugs using secondary data sources. Price is typically either estimated from self-report surveys or from under-cover police drug buying operations. Consumption on the other hand, is typically measured either directly via self-report surveys (e.g. Becker, Grossman & Murphy 1991; Grossman & Chaloupka 1998; Saffer & Chaloupka 1999; see Grossman et al. 2002 for a review) or indirectly from administrative data sources such as drug-related emergency department admissions or the proportion of arrestees testing positive for drugs (Silverman & Spruill, 1977; Caulkins, 1995; 2001; Dave, 2004; 2006). Manski, Pepper and Petrie (2001) reviewed a large number of studies that used both direct and indirect methods and estimated that the own-price elasticity of demand for cocaine ranged from -.59 to -2.5 (i.e. ranging from relatively inelastic to highly elastic).

There is strong evidence from studies that use direct measures of use that own-price elasticity of demand for heroin is relatively elastic. Saffer and Chaloupka (1999), for example, estimated the price of cocaine and heroin from the US Department of Justice's database of undercover drug purchases and measured consumption based on the pooled 1988, 1990 and 1991 national household drug use surveys. Saffer and Chaloupka estimated that a 10 per cent increase in the price of cocaine and heroin would result in 2.8 and a 9.4 per cent decrease in participation in cocaine and heroin, respectively. While the studies based on direct measures of use provide important insights into the elasticity of demand for drugs, the self-reported drug use data tend to be collected via household or telephone surveys which by their very nature exclude marginalised populations, including those who might be at greatest risk of being dependent on illicit drugs. This can be a problem when estimating price elasticity because dependent users might be less able than non-dependent users to curb their consumption in response to price increases.

Indirect measures of drug use might better reflect the experiences of dependent users because those who use drugs most frequently are also most likely to come into contact with public agencies such as hospitals or police. While most well-conducted studies that have employed indirect measures of use tend to also find some responsiveness to price changes, the elasticity estimates have varied considerably. For example, using data derived from arrestees and from hospital emergency room admissions, Caulkins (1995; 2001) estimated the own-price elasticity of demand for cocaine to be between -1.3 and -2.5 and own-price elasticity of demand for heroin/morphine to be between -.84 and -1.5. On the other hand, Dave (2004; 2006) used similar data but a different analytical methodology and estimated much more modest short-run elasticities. In fact, Dave concluded that demand falls within the inelastic range (-.15 to -.27 for cocaine and -.08 to -.10 for heroin).

Most of the studies reviewed above examined the impact of the declining heroin prices in post-Vietnam war America and, in particular, the crack cocaine epidemic that took hold in America in the 1980s. In Australia, the heroin shortage that manifested itself around Christmas 2000 provided compelling support for the notion that demand for heroin might be relatively elastic. When the real price of heroin more than doubled in a very short space of time, consumption of the drug reduced dramatically, as did other indicators of drug related harm such as fatal and non-fatal overdoses and drug-related property offences (Moffatt, Weatherburn & Donnelly 2005; Smithson et al. 2004; Weatherburn et al. 2003). While specific price elasticities were not estimated in relation to the heroin shortage, Weatherburn and colleagues (2003) estimated from their survey of 167 injecting drug users that a one per cent increase in the price per pure gram of heroin resulted in a 0.32 per cent fall in expenditure on the drug.

In summary, the prevailing view, based on direct and indirect observations of drug consumption measures, is that consumption of illicit drugs such as heroin and cocaine is responsive to changes in price. However, the actual elasticity estimates vary depending on the populations, data sources and methodologies employed. The economic research community is far less certain about the implications of price changes in one drug for the consumption of other drugs. Analyses of drug use among the general population tend to find that alcohol is a complement for illicit drugs (e.g. Saffer and Chaloupka, 1999; Pacula 1998). Furthermore, Saffer and Chaloupka (1999) found complementarity between illicit drugs such as heroin, cocaine and cannabis. Studies using indirect measures of illicit drug use also tend to find complementarity between heroin and cocaine use (e.g. Dave 2004; 2006). Research into the effects of the Australian heroin shortage found that a proportion of heroin users substituted their use – at least in the short term – with other drugs such as cocaine and methamphetamine (Maher et al. 2007; Weatherburn et al. 2003). It is important to point out, however, that these studies observed drug substitution among those users who were still by definition in the market and this substitution does not appear to have occurred at a more aggregate level (Snowball et al. 2008). Nevertheless, this research does suggest that heroin and psycho-stimulant drugs might act as short-term substitutes for some frequent substance users.

The literature reviewed above clearly shows that estimates of price elasticity vary markedly depending on the population under study, the nature of the drug in question and the methodology employed to correlate measures of price and consumption. Manski, Pepper and Petrie (2001) outline several reasons for these varying estimates, including the lack of uniform price data, the variation in prices charged (even by the same dealer) and the heterogeneity of drug users. For this reason, a growing body of overseas literature has employed behavioural economics techniques to explore responsiveness of demand in a more controlled environment (Cole et al. 2008; Goudie et al. 2007; Petry 2000; Petry & Bickel 1998; Sumnall et al. 2004). These studies make use of experimental data, whereby current or former drug users typically make hypothetical purchases of a range of drugs using imitation money provided by the researcher. Participants are given a price list outlining several different drugs and are subsequently asked how much of each drug they would purchase given a fixed drug budget. The researcher then changes the prices of the various drugs over successive trials and records the participants' drug purchases at each of the drug prices. The resulting purchase data is used to determine own- and cross-price elasticities. The theory behind this methodological approach is that, by virtue of making these purchases in a controlled environment, any observed changes in hypothetical consumption should be attributed entirely to changes in price. When purchased in a natural setting the quality of the drug can, and often does, vary with price.

In a classic study of this kind conducted in the United States, Petry and Bickel (1998) found that the decrease in consumption of heroin was roughly proportional to the increase in its price among a group of current and former opioid-dependent participants. In contrast to the results of studies using secondary data sources (Dave, 2004; 2006), Petry and Bickel found evidence of substitution between illicit drugs. Increases in the price of heroin induced relatively strong substitution into valium and cocaine (cross-price elasticities of 1.02 and 0.8, respectively) with more moderate substitution into cannabis and alcohol (elasticities for both were 0.5).[4] In a more recent study, Jofre-Bonet and Petry (2008) also found that the own-price elasticities of demand for cocaine and heroin were close to one, regardless of levels of dependence on one or other of the drugs. Heroin-dependent people were found to complement their heroin use with cocaine, alcohol and cannabis. The only substitute for heroin was valium. Cocaine-dependent people complemented their cocaine use with heroin and alcohol but substituted into cannabis and valium. In the only study to consider amphetamine use, Sumnall and colleagues (2004) found that demand for amphetamine, cocaine and ecstasy was quite elastic among poly-substance recreational users in the UK. That is, purchases of each of these drugs decreased at a proportionately greater rate than the associated increase in price. Further, this study revealed that for this population, alcohol was a substitute for amphetamine, while ecstasy and cocaine purchases were independent of amphetamine prices.

There is clearly still much to be learned about how methamphetamine users respond when faced with significant changes in price. We cannot be sure that samples of Australian drug users would respond in the same way as those studied internationally. Furthermore, it may be the case that responsiveness to changes in price varies according to the characteristics of those who use drugs (e.g. contingent on their levels of dependence on heroin and/or methamphetamine) and the drug market inhabited by the drug user. This is an important knowledge gap in light of the considerable investment Australian law enforcement agencies make in attempting to curb illicit drug supply. The current study used behavioural economics techniques to examine the elasticity of demand for methamphetamine among a sample of Australian methamphetamine users. Because it is well established that there is a high degree of poly-drug use among populations of injecting drug users (Darke & Hall 1995), we also examined how this group would respond to changes in the price of heroin. Participants were presented with hypothetical drug buying scenarios and the price of methamphetamine and heroin were systematically varied to determine how consumption would likely respond to changes in drug price.

The specific research questions that the current study aimed to address were:

(a) How much would consumption of methamphetamine change in response to changes in its price?

(b) How much would consumption of heroin change in response to changes in its price?

(c) How much would consumption of other drugs change in response to changes in the price of methamphetamine or heroin?

(d) Does responsiveness of consumption vary according to whether the participant is dependent on methamphetamine or heroin?

# METHOD

## PROCEDURE

The methodology, in large part, follows that of Petry and Bickel (1998). Interviews were conducted between August and November 2008 by six trained interviewers. One hundred and one people who were at least 18 years of age and who reported using methamphetamine in the previous month were recruited into the study. Potential participants were identified through their attendance at one of four cooperating agencies in Sydney, Newcastle or Wollongong. Each of the agencies included a needle and syringe programme. In the first instance, participants were directly approached by the researchers and invited to undertake a face-to-face interview. Snowball sampling was also used, whereby participants who had completed the survey informed their friends about the study and these potential participants approached the researchers. There was no intent to sample a representative group of methamphetamine users. Prior to participating in the interview, the nature of the study was explained and participants were advised that any information provided would be treated confidentially. All survey participants then signed written consent forms.

Most interviews were conducted on site at one of the four agencies, although a small number of interviews were conducted at a public housing estate where the local needle and syringe program provided a mobile service. During each interview, the interviewer read out all questions and recorded participant responses on a paper copy of the questionnaire. Each interview ran for 30 to 45 minutes and participants were reimbursed $30 as compensation for their time at the completion of the survey.

## QUESTIONNAIRE

The critical part of the questionnaire involved a series of questions about hypothetical drug purchases across a range of drug prices. The interviewer read aloud the following instructions:

> "Think of a typical week. We are going to use a price list and some pretend money to play a sort of game. Assume that you have $200 that you can use to buy drugs for that week or the length of time it would normally take you to spend $200 on drugs. The drugs that are available to you and the price of those drugs are listed on this sheet."

The amount of each participant's drug budget was held constant at $200 during the experiment.[5] The size of the drug budget approximates the weekly income support received by single unemployed Australians at the time of the interviews. As the majority of the study participants relied on income support as their primary source of income, this budget was intended to provide a realistic frame of reference for the hypothetical purchases. Participants were told that they did not have to spend all of the $200 on the listed drugs and were advised to hypothetically purchase drugs at the rate they normally would. As a result, the timeframe over which participants could spend the $200 budget was allowed to vary. For some participants, this budget was sufficient to cover their actual weekly usage, while it would be clearly insufficient for other respondents.

Each price list included the following drugs: heroin, methamphetamine (base, powder or crystal), cannabis, cocaine, non-prescription benzodiazepines, alcohol, and non-prescription pharmaceutical opioids (i.e. oxycodone and morphine). The price of each drug reflects the average price from the 2008 Illicit Drug Reporting System (IDRS) survey (Phillips and Burns 2009). The baseline prices were $50 per cap of heroin, $50 per point of base, powder or crystal methamphetamine, $20 per gram of cannabis, $50 per cap of cocaine, $2 per benzodiazepine pill, $30 per pharmaceutical opioid pill[6] and $5 per unit of alcohol. Only one quantity per drug was employed to avoid issues of quantity discounting.

The interviewer then explained the "rules" of the game, as follows:

> "You may buy any drugs that you like with this money, but you can only spend $200 on drugs. No other drugs are available

to you aside from those you buy with this money. For example, you cannot use drugs given to you by a friend and you cannot buy any more drugs once you have spent the $200. Even if you have drugs stashed away, you cannot use them. You can't bargain with your dealer or buy in bulk to reduce the price. Also, you cannot use the $200 to buy a drug not listed. The drugs that you buy can only be used by you and cannot be given away or sold. Finally, the prices of some of the drugs will change across the different price lists but the quality of the drugs does not change with price changes. The drugs are of the same quality that you'd expect to get from your regular supplier and when the drug prices change I want you to imagine that the prices will stay that way for the foreseeable future. Please purchase the drugs you would like from the list."

Illicit drug market adjustments do not only manifest as changes in the price of a drug. More often than not it is the purity or quality of the drug that fluctuates and price changes tend to be accompanied by variations in the purity or quality of the drug (Caulkins 2007). Hence, it was important to impress upon participants that the quality did not vary with price.

Following the presentation of the base price list, eight further price lists were presented to each participant in a randomised order and the prices of methamphetamine and heroin were varied one at a time with each successive presentation. In addition to the baseline prices of $50 per cap of heroin or point of methamphetamine the following prices were presented for both drugs: $10, $20, $75, and $100. This range of prices was selected because it was within the bounds of what street-based samples of illicit drug users in Sydney reported paying for heroin and methamphetamine (Phillips and Burns 2009).

A number of other measures were also collected from participants both to contextualise the patterns of drug use among this sample and to observe how these characteristics interacted with willingness to purchase methamphetamine and other drugs. These characteristics included a range of demographic characteristics (e.g. age, sex), patterns of drug use, severity of dependence on methamphetamine and severity of dependence on heroin (as indexed by the Severity of Dependence Scale; Gossop et al. 1995).

### ANALYSIS

The behavioural economics literature has typically measured price elasticity in terms of the bivariate relationship between hypothetical purchases (or consumption) and drug prices, operationalised as the percentage change in hypothetical consumption in relation to the percentage change in price. The own-price elasticities for methamphetamine and heroin and cross-price elasticities for all the drugs in relation to the prices of both methamphetamine and heroin are measured by the slope of the plot of the price and consumption on log-log coordinates calculated by linear regression (Petry and Bickel 1998; Petry 2000; Goudie et al. 2007). We follow this methodology by estimating the impact of methamphetamine price on the amount of each drug purchased.

The data obtained from this survey contain two features that complicate the analysis of changes in the quantity of drugs purchased. Firstly, all of the 101 participants provided multiple purchase amounts in response to the nine unique price lists. It is problematic to analyse the data as though the hypothetical purchases represent a simple random sample because responses are correlated within individuals. In other words, the amount any individual is willing to purchase at a given price is highly related to the amount they are willing to purchase at another drug price. The second complicating feature of these data is that the hypothetical units of a drug purchased are non-negative integers, or counts (e.g. 0, 1, 2, 3, … 20 points of methamphetamine). Because these count data are bounded by zero and concentrated around a few discrete values – often close to zero – the distribution is highly skewed. The discrete, skewed and non-independent nature of the data violates the assumptions that underpin ordinary least squares regression and alternative regression techniques were employed to estimate the elasticities reported in this bulletin. Several models were considered but ultimately zero-inflated negative binomial and zero-inflated poisson models were found to provide the best fit to the data.[7] All analyses were undertaken using Stata/SE 10.1. Stata's cluster estimator of the variance covariance matrix was used to account for the non-independent nature of the outcome variable (Baum 2006, pp. 138-139).

### CALCULATING PRICE ELASTICITY FROM COUNT DATA ANALYSIS

The estimated coefficient for a continuous explanatory variable (such as price) represents the proportionate change in hypothetical purchases brought about by a $1 change in price, with all explanatory variables set to their mean values. The estimated elasticity with respect to price is simply the mean price ($51) multiplied by the estimated coefficient (Cameron et al. 1998).

## RESULTS

### PARTICIPANTS

The characteristics of the 101 participants are summarised in Table 1. Most participants were men (n=58). The mean age of participants was 38.6 years (range=18-58) and 84 had not completed any formal education beyond years 10 or 11 of school. A little over half of the participants (n=52) reported that their primary source of income was income support. All but five of the respondents indicated that they usually purchased the illicit drugs that they used. On average, participants reported that they were 16 years of age when they first used any illicit drug and 21 years old when they first used methamphetamine.

Heroin was the most often cited main drug of choice at the time of the interview (n=42) with a third of respondents citing methamphetamine as their main drug of choice (n=33). One quarter (n=26) of the respondents reported that methamphetamine was the last drug used while 39 participants last used heroin.

**Table 1. Descriptive characteristics of the sample of methamphetamine users (n=101)**

| *Characteristic* | | *%* | *Mean (SD)* |
|---|---|---|---|
| Men | | 57.4 | - |
| Age | (years) | - | 38.6 (7.9) |
| Education | Tertiary/TAFE/Trade | 16.8 | - |
| | Year 10/11 or secondary | 34.7 | - |
| | Less than year 10/11 | 48.5 | - |
| Primary source of income | Employment | 11.9 | - |
| | Income support | 55.4 | - |
| | Dealing/scoring | 8.9 | - |
| | Other crime/sex work | 14.9 | - |
| | Other | 12.9 | - |
| I usually purchase the drugs I use | | 95.1 | - |
| Age at first use of an illicit drug | | - | 15.6 (4.8) |
| Age first used methamphetamine | | - | 21.4 (7.9) |
| Main drug of choice | Methamphetamine | 32.7 | - |
| | Heroin | 41.6 | - |
| | Other | 25.7 | - |
| Last drug used | Methamphetamine | 25.7 | - |
| | Heroin | 38.6 | - |
| | Other | 35.7 | - |
| Lifetime use | Methamphetamine | 100 | - |
| | Heroin | 96 | - |
| | Cocaine | 87.1 | - |
| | Alcohol | 96 | - |
| | Cannabis | 100 | - |
| | Benzodiazepines | 72.1 | - |
| | Other opioids | 90.1 | - |
| Used in past month | Methamphetamine | 100 | - |
| | Heroin | 77.2 | - |
| | Cocaine | 43.6 | - |
| | Alcohol | 69.3 | - |
| | Cannabis | 87.3 | - |
| | Benzodiazepines | 65.3 | - |
| | Other opioids | 52.5 | - |
| Daily use* | Methamphetamine | 34.7 | - |
| | Heroin | 35.6 | - |
| | Cocaine | 5.9 | - |
| | Alcohol | 15.8 | - |
| | Cannabis | 58.4 | - |
| Methamphetamine form most recently used | Powder | 14.9 | - |
| | Base | 13.9 | - |
| | Ice/crystal | 70.3 | - |
| | Other | 1 | - |
| Route of administration of most recent use | Inject | 91.1 | - |
| | Smoke | 6.9 | - |
| | Swallow | 1 | - |
| | Other | 1 | - |
| Dependent | Methamphetamine** | 64.4 | - |
| | Heroin*** | 70.3 | - |

** Daily use is at least 28 days per month*

*** Using a cut-off of 4 on severity of dependence scale (Topp and Mattick, 1997)*

**** Using a cut-off of 3 on severity of dependence scale (González-Sáiz et al., 2009)*

Thirty-five per cent of the respondents reported consuming methamphetamine on seven or fewer days in the month preceding the interview and a similar number reported using methamphetamine daily. Over one third (n=36) of the participants reported using heroin daily while 23 had not used heroin in the past month. Crystalline methamphetamine (commonly known as 'ice') was the form of methamphetamine most recently used by 71 participants. Over 90 per cent of participants injected methamphetamine and seven per cent smoked it on their last occasion of use. Two-thirds of the respondents (n=65) met the criteria for methamphetamine dependence, which reflects the highly addictive nature of the drug, particularly when smoked or injected (Cho and Melega 2002; McKetin et al. 2008). Seventy per cent of the respondents met the criteria for heroin dependence. Almost all respondents who had used heroin in the past month met the criteria for heroin dependence. Only 10 of the respondents were not dependent on one or both of these drugs. Seventy per cent of those dependent on methamphetamine were also dependent on heroin. Less than half (46%) of those dependent on methamphetamine reported that methamphetamine was their drug of choice while just over half of those dependent on heroin reported heroin as their drug of choice.

## DESCRIPTIVE OVERVIEW OF DRUG PURCHASING BEHAVIOUR

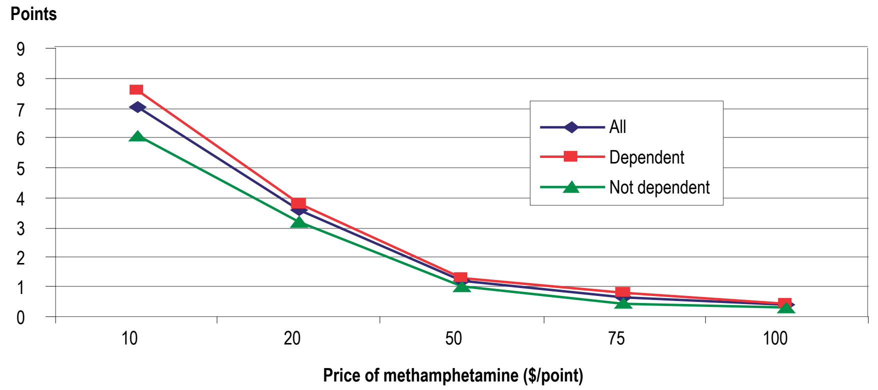
There were 909 hypothetical purchases for each drug listed (i.e. 9 lists x 101 participants). Following the behavioural economics literature we assessed the reliability of the hypothetical purchases by calculating the strength of the relationships between the total amounts of each drug purchased over the nine price lists and self-reported days of use of that drug in the past month. Spearman rank order correlation coefficients between hypothetical purchases and actual use were significant at the one per cent level for methamphetamine, cocaine, heroin, cannabis and alcohol, and significant at the five per cent level for benzodiazepines. We were unable to calculate the correlation for pharmaceutical opioids because we collected information on the daily use of morphine and oxycodone individually rather than the daily use of either drug. Collectively, these findings suggested that the participants' hypothetical purchases were highly correlated with their actual reported use of each drug.

Two groupings of hypothetical purchases were constructed for the analysis: 505 related to variation in the price of methamphetamine (i.e. 5 lists x 101 participants) and 505 related to the variation in the heroin price. One hundred and one hypothetical purchases were common to both groups, which were those pertaining to the baseline price list with the price of heroin set to $50 per cap and the price of methamphetamine set to $50 per point.

The own-price responsiveness of hypothetical drug purchases to variations in the prices of methamphetamine and heroin are depicted graphically in Figures 1a and 1b. It is clear from both figures that methamphetamine and heroin purchases both decrease sharply with increases in their own-price; with methamphetamine falling from 7.03 points to 0.42 points as the price of methamphetamine increased from $10 to $100 and heroin falling from 6.85 caps to 0.54 caps in response to a similar increase in the price of heroin. Among participants dependent on methamphetamine the extent of the reduction in methamphetamine purchases was from 7.57 to 0.48 points. This is similar to the decrease from 6.06 to 0.31 points observed among the non-dependent group. Heroin dependence had a greater influence on heroin purchases. The heroin-dependent group decreased their purchases from an average of 8.79 caps to 0.75 caps when the price increased from $10 to $100. In comparison, the non-dependent group decreased their purchases from 2.27 to 0.03 caps. These changes in purchases were all highly statistically significant.[8]

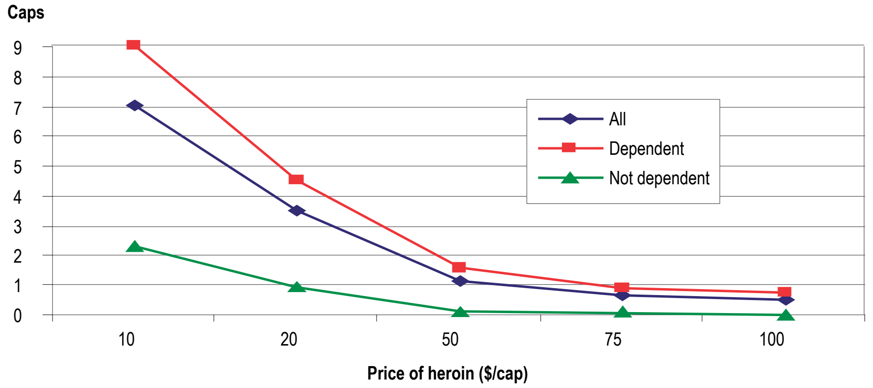
Figure 2a shows the proportion of respondents who reported that they would purchase methamphetamine at each price as well as the quantity purchased

**Figure 1a. Average hypothetical purchases of methamphetamine as the price of methamphetamine was varied across the trials, by extent of methamphetamine dependence**




*Note: price of heroin fixed at $50/cap*

**Figure 1b. Average hypothetical purchases of heroin as the price of heroin was varied across the trials, by extent of heroin dependence**




*Note: price of methamphetamine fixed at $50/point*

**Figure 2a. Proportion of respondents reporting that they would buy methamphetamine and amount purchased if bought in relation to price of methamphetamine by level of dependence**

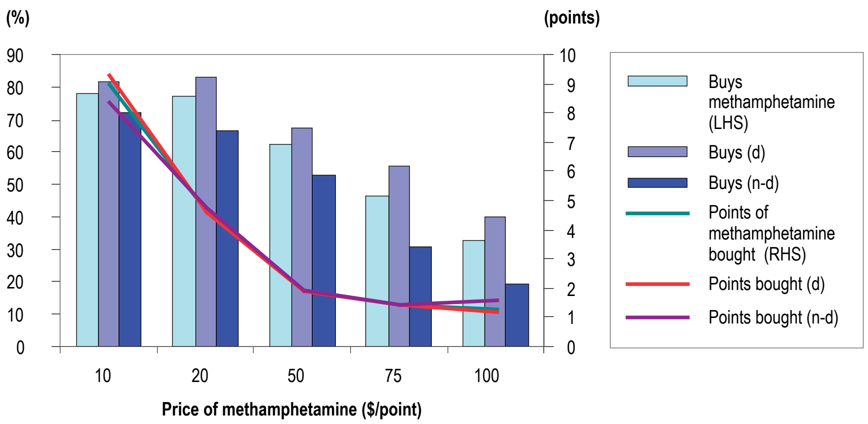


**Figure 2b. Proportion of respondents reporting that they would buy heroin and amount purchased if bought in relation to price of heroin by level of dependence**

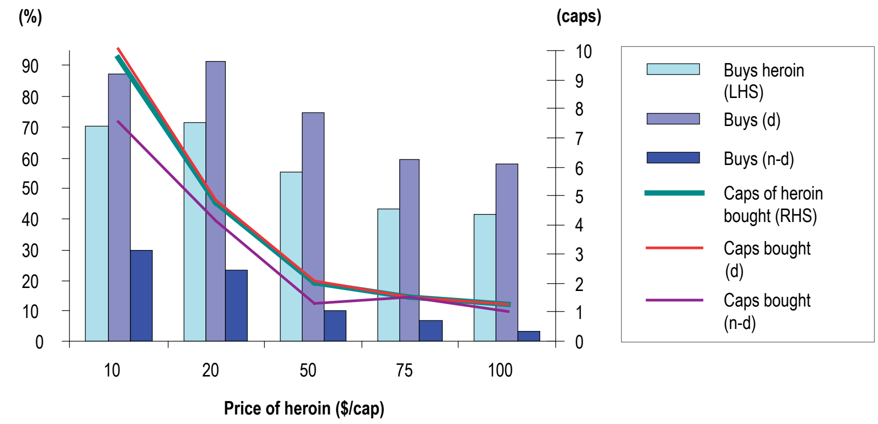



**Figure 3a. Average hypothetical purchases of alternate drugs as the price of methamphetamine was varied across the trials**

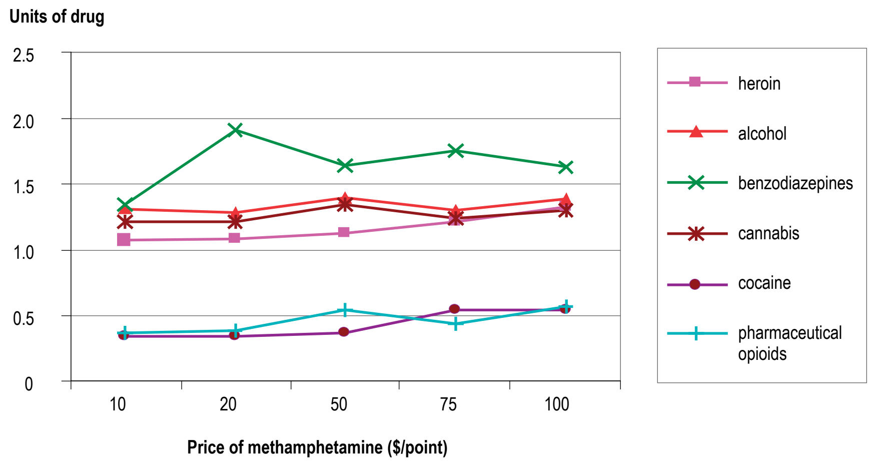
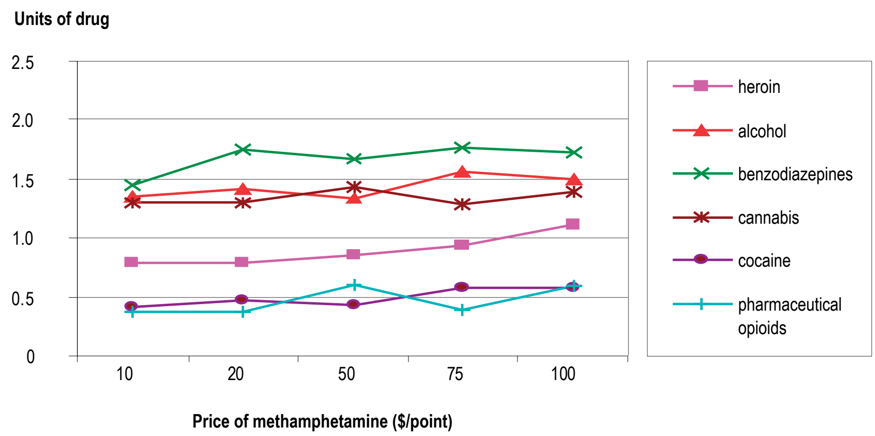



**Figure 3b. Average hypothetical purchases of alternate drugs as the price of methamphetamine was varied across the trials – methamphetamine dependent**



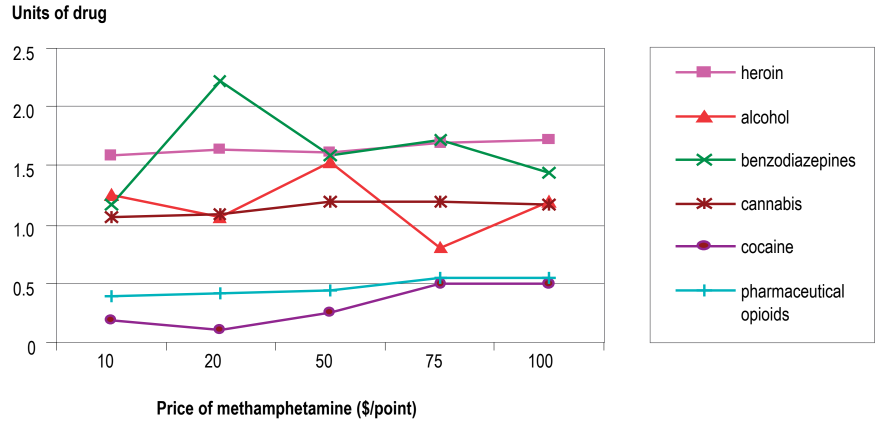

(averaged across only those who would be willing to buy at that price). Figure 2b shows the analogous responses for heroin purchases. Those dependent on methamphetamine and particularly those who were dependent on heroin were more likely than non-dependent participants to purchase those drugs at any price. While those who were dependent on heroin tended to buy slightly more of the drug at prices of $50 and lower, dependent and non-dependent methamphetamine users purchased roughly the same number of units of methamphetamine at each price.

For participants who did not meet the criteria for methamphetamine or heroin dependence, it is clear that willingness to purchase that drug is inversely related to the price, since the proportion of people who purchase each drug falls with every price increase. Among those dependent on the drug in question the tendency to purchase the drug varied little with price changes between $10 and $20 but the proportion willing to buy decreased at higher drug prices. Interestingly, increases in drug price beyond the $50 baseline did not greatly affect the amount purchased but decreases in the price of heroin and methamphetamine below the baseline price resulted in large increases in the amount purchased.

Figures 3a, 3b and 3c show how average purchases of the other drugs available on the pricelist responded to movements in the methamphetamine price for all respondents, those dependent on methamphetamine and those not dependent on methamphetamine, respectively. Visually, the most marked relationships to emerge from these graphs were the positive correlations between both heroin and cocaine purchases, and methamphetamine price, for the dependent and non-dependent groups. Pharmaceutical opioid purchases appeared also to rise with methamphetamine price, but less markedly, as did purchases of cannabis in the non-dependent group.

Figures 4a, 4b and 4c show how average purchases of these other drugs changed in response to movements in the heroin price. Responses tended

**Figure 3c. Average hypothetical purchases of alternate drugs as the price of methamphetamine was varied across the trials – not methamphetamine dependent**




A ten per cent increase in the price of methamphetamine was estimated to lead to a 2.00 per cent increase in heroin consumption and a 3.33 per cent increase in pharmaceutical opioid purchases.

For non-dependent methamphetamine users, the own-price elasticity of demand was again estimated to be elastic (-1.866), suggesting that a ten per cent increase in the price of methamphetamine would result in an 18.66 per cent reduction in the quantity of methamphetamine purchased. There was evidence of substitution into heroin, cannabis, cocaine and pharmaceutical opioids, although this substitution was only statistically significant for heroin and cocaine. A ten per cent increase in the price of methamphetamine was estimated to lead to a 0.54 per cent increase in heroin consumption and a 7.05 per cent increase in cocaine consumption. There was some evidence that alcohol and benzodiazepines were complements for methamphetamine in this group but the elasticities were not statistically significant (-0.046 and -0.152, respectively).

to differ between dependent and non-dependent participants. Looking firstly at the dependent group (Figure 4b), the most striking feature is the large increase in benzodiazepine purchases as heroin price increased. There were also increases in pharmaceutical opioid, methamphetamine and, perhaps to a lesser extent, alcohol purchases at higher heroin prices. Cocaine purchases tended to decrease as the heroin price rose. For the non-dependent group, the only clear relationship was a significant increase in pharmaceutical opioid purchases with rising heroin prices. Benzodiazepine purchases increased at the highest heroin price, cannabis decreased at the lowest heroin prices and alcohol purchases tended to decrease as price both increased and decreased from the baseline.[9]

## ELASTICITY OF DEMAND FOR METHAMPHETAMINE AND HEROIN

The estimated elasticities calculated from the regression analysis are presented in Table 2. Turning first to those assessed as being dependent on methamphetamine, Table 2 shows the estimated own-price elasticity of demand to be elastic (-1.766). This suggests that a ten per cent increase in the price of methamphetamine was estimated to result in a 17.66 per cent reduction in the quantity of methamphetamine purchased. Among this group, an increase in the price of methamphetamine was associated with increased purchases of most other drugs. While there was evidence of substitution, the only statistically significant substitution was for heroin and pharmaceutical opioids.

Turning next to responsiveness to changes in heroin price among heroin-dependent users, the own-price elasticity was also estimated to be in the elastic range (-1.553). A 10 per cent increase in the price of heroin was estimated to result in a 15.53 per cent reduction in the amount of heroin purchased. Contrary to the results for changes in methamphetamine price, cocaine (-0.538) was found to be a complement for heroin while benzodiazepines (0.308), pharmaceutical opioids (0.395) and

**Table 2. Own-price and cross-price elasticity of demand when methamphetamine and heroin price change**

| | *Meth.* | *Heroin* | *Alcohol* | *Cann.* | *Cocaine* | *Pharm. opioids* | *Benzos* |
|---|---|---|---|---|---|---|---|
| Methamphetamine price | | | | | | | |
| Methamphetamine dependent | -1.766*** | 0.200*** | -0.011 | 0.050 | 0.121 | 0.333*** | 0.070 |
| Not methamphetamine dependent | -1.866*** | 0.054** | -0.046 | 0.036 | 0.705*** | 0.137 | -0.152 |
| Heroin price | | | | | | | |
| Heroin dependent | 0.255*** | -1.553*** | 0.099 | -0.094 | -0.538*** | 0.395*** | 0.308*** |
| Not heroin dependent | 0.013 | -2.674*** | -0.009 | 0.038 | -0.202 | 0.764* | 0.054 |

**** p<=.01, ** p<=.05, *p<=.10*

**Figure 4a. Average hypothetical purchases of alternate drugs as the price of heroin was varied across the trials**

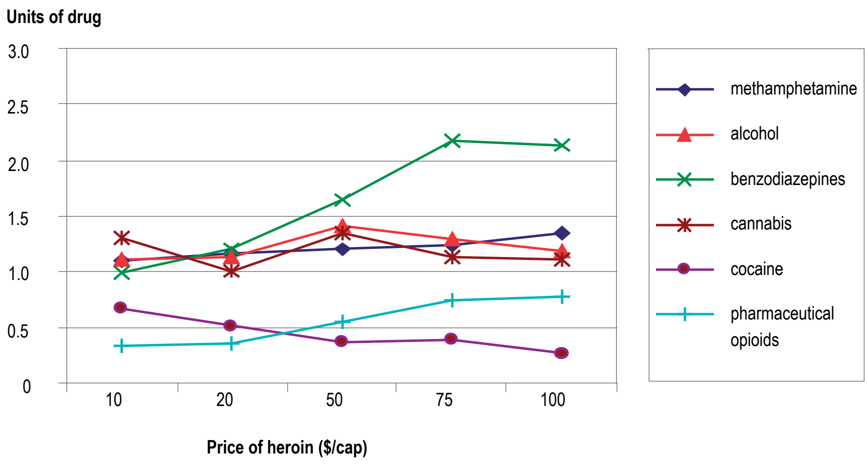



**Figure 4b. Average hypothetical purchases of alternate drugs as the price of heroin was varied across the trials – heroin dependent**

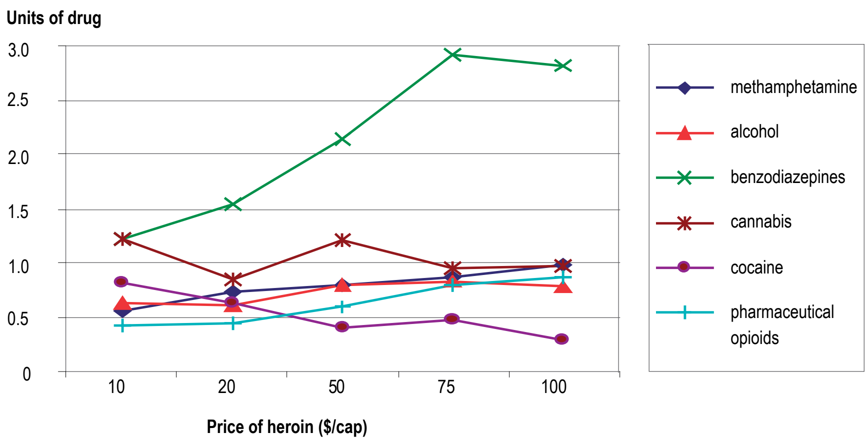
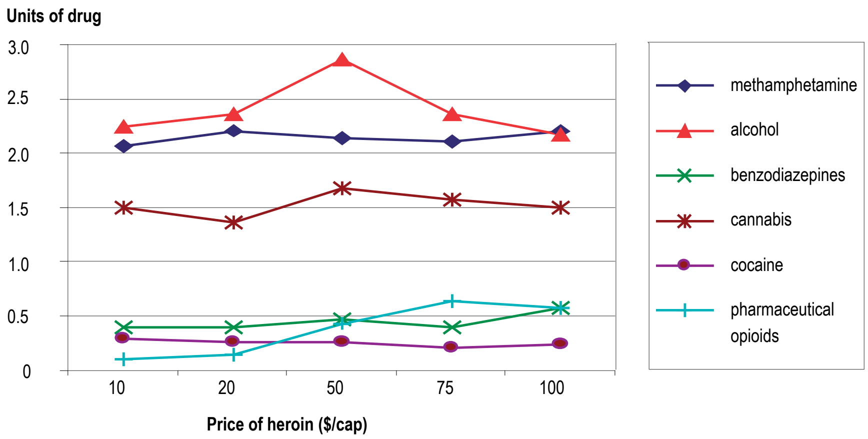



**Figure 4c. Average hypothetical purchases of alternate drugs as the price of heroin was varied across the trials – not heroin dependent**




methamphetamine (0.255) were found to be substitutes. A ten per cent increase in the price of heroin was estimated to lead to a 5.38 per cent decrease in cocaine consumption, a 3.08 per cent increase in benzodiazepine consumption, a 3.95 per cent increase in pharmaceutical opioid purchases and a 2.55 per cent increase in methamphetamine consumption.

Turning lastly to the results for non-dependent heroin users, the own-price responsiveness was highly elastic (-2.674), which indicates a greater than 26 per cent reduction in consumption for heroin with each 10 per cent increase in its price. There was evidence of substitution into pharmaceutical opioid consumption (cross-price elasticity = 0.764). While cocaine appeared to complement heroin use among this group (cross-price elasticity = -0.202), this complementarity was not statistically significant.

## IMPACT OF PRICE CHANGES ON TOTAL CONSUMPTION

While the elasticities shown in Table 2 indicate that there is some substitution into other drugs when the price of methamphetamine and heroin rise, the net effect of changes in the price of these drugs cannot be assessed without accounting for the base rates of consumption of these drugs.[10] For example, while there is strong evidence of substitution into cocaine use when the price of methamphetamine increased, the base rate of consumption of cocaine was quite low among this group. Even if cocaine use doubled, therefore, it would not be enough to offset the benefits associated with the decrease in methamphetamine use.

Table 3a shows the total number of units of each drug purchased at each methamphetamine price. The table has three sections: the top section reports drug purchases for all participants; the second section reports purchases for the subset of 65 participants who met the criteria for methamphetamine dependence and the third section reports purchases for the 36 participants who did not meet the criteria for methamphetamine dependence.

Looking first at the results for the whole sample, the most striking finding is the large increase in units of methamphetamine purchased at lower methamphetamine prices. At baseline, participants purchased 121 points of methamphetamine. This increased by almost 200 per cent when the price was $20 (to 362 units) and by almost 500 per cent (to 710 units) when the price was $10. It is also clear that there was some substitution into heroin at higher methamphetamine prices (by 18% to 134 caps at the highest methamphetamine price). While there was also evidence of substitution into cocaine and pharmaceutical opioids, the base rate of use of both of these substitutes was quite low. Participants only bought 37 units of cocaine and 55 units of pharmaceutical opioids at baseline prices.

Consistent with the results shown in Table 2, there was some evidence that dependence played a small role in determining responses to price reductions. Dependent methamphetamine users tended to be slightly less responsive to changes in methamphetamine price increases than non-dependent users. For example, dependent users purchased 38 per cent less methamphetamine by volume when the price rose to $75, compared with a 57 per cent reduction among non-dependent users. Dependent users also tended to show greater overall increases in heroin consumption at higher methamphetamine prices than non-dependent users. Table 3a also reveals that the strong substitution into cocaine use among non-dependent users comes off a low base rate of use of nine caps at the baseline price of $50.

Table 3b shows the analogous results when heroin prices were varied. Among the whole sample, there was again a large increase in units of heroin purchased at lower heroin prices. At baseline, participants purchased 114 caps of heroin. This increased by approximately 200 per cent when the price was $20 (to 344 caps) and by more than 500 per cent (to 692

### Table 3a. Drugs bought at each methamphetamine price with percentage difference from baseline in brackets*

| | *Price of methamphetamine (point)* | | | | |
|---|---|---|---|---|---|
| | ***10*** | ***20*** | ***50*** | ***75*** | ***100*** |
| Methamphetamine (points) | 710(487) | 362(199) | 121 | 68(-44) | 42(-65) |
| Heroin (caps) | 108(-5) | 110(-4) | 114 | 122(7) | 134(18) |
| Alcohol (drinks) | 133(-6) | 130(-8) | 142 | 131(-8) | 140(-1) |
| Benzodiazepines (pills) | 136(-18) | 194(17) | 166 | 177(7) | 164(-1) |
| Cannabis (grams) | 122(-10) | 123(-10) | 136 | 126(-7) | 132(-3) |
| Cocaine (caps) | 34(-8) | 34(-8) | 37 | 55(49) | 55(49) |
| Pharmaceutical opioids (pills) | 38(-31) | 39(-29) | 55 | 45(-18) | 58(5) |
| **Methamphetamine dependent (n=65)** | | | | | |
| Methamphetamine (points) | 492(486) | 248(195) | 84 | 52(-38) | 31(-63) |
| Heroin (caps) | 51(-9) | 51(-9) | 56 | 61(9) | 72(29) |
| Alcohol (drinks) | 88(1) | 92(6) | 87 | 102(17) | 97(11) |
| Benzodiazepines (pills) | 94(-14) | 114(5) | 109 | 115(6) | 112(3) |
| Cannabis (grams) | 84(-10) | 84(-10) | 93 | 83(-11) | 90(-3) |
| Cocaine (caps) | 27(-44) | 30(7) | 28 | 37(32) | 37(32) |
| Pharmaceutical opioids (pills) | 24(-38) | 24(-38) | 39 | 25(-36) | 38(-3) |
| **Not methamphetamine dependent (n=36)** | | | | | |
| Methamphetamine (points) | 218(489) | 114(208) | 37 | 16(-57) | 11(-70) |
| Heroin (caps) | 57(-2) | 59(2) | 58 | 61(5) | 62(7) |
| Alcohol (drinks) | 45(-18) | 38(-31) | 55 | 29(-47) | 43(-22) |
| Benzodiazepines (pills) | 42(-26) | 80(40) | 57 | 62(9) | 52(-9) |
| Cannabis (grams) | 38(-12) | 39(-9) | 43 | 43(0) | 42(-2) |
| Cocaine (caps) | 7(-22) | 4(-56) | 9 | 18(100) | 18(100) |
| Pharmaceutical opioids (pills) | 14(-13) | 15(-6) | 16 | 20(25) | 20(25) |

caps) when the price was $10. Among all respondents there was evidence of strong substitution into benzodiazepines and methamphetamine and these increases came off high base rates of use (166 pills and 121 caps purchased at the baseline heroin price of $50). The substitution into pharmaceutical opioids shown in Table 2, on the other hand, comes off a low base rate of use of these drugs (55 pills at the baseline heroin price). Similarly, the complementarity observed among cocaine purchases related to low base rates of use (37 caps at the baseline heroin price).

The disparity between dependent and non-dependent heroin users observed in Table 2 is also apparent in Table 3b. However, while non-dependent heroin users were indeed much more responsive to changes in heroin price than dependent users (increasing their purchases by 1600% at the lowest price), baseline heroin consumption was very low among the non-dependent group. These 30 participants only purchased four caps of heroin at the baseline price of $50. As a result, the largest changes in overall consumption were observed among the dependent group. The large overall substitution into benzodiazepines was manifest only among heroin-dependent users who purchased 152 of the 166 pills purchased at the baseline heroin price. Similarly, the substitution into methamphetamine was only observed among heroin-dependent users.

**Table 3b. Drugs bought at each heroin price with percentage difference from baseline in brackets***

| | *Price of heroin ($ per cap)* | | | | |
|---|---|---|---|---|---|
| | *10* | *20* | *50* | *75* | *100* |
| Methamphetamine (points) | 102(-16) | 118(-2) | 121 | 124(2) | 136(12) |
| Heroin (caps) | 692(507) | 344(202) | 114 | 66(-42) | 54(-53) |
| Alcohol (drinks) | 112(-21) | 114(-20) | 142 | 130(-8) | 120(-15) |
| Benzodiazepines (pills) | 99(-40) | 122(-27) | 166 | 219(32) | 217(31) |
| Cannabis (grams) | 132(-3) | 101(-26) | 136 | 114(-16) | 113(-17) |
| Cocaine (caps) | 67(81) | 52(41) | 37 | 40(8) | 27(-27) |
| Pharmaceutical opioids (pills) | 33(-40) | 35(-36) | 55 | 75(36) | 78(42) |
| **Heroin dependent (n=71)** | | | | | |
| Methamphetamine (points) | 40(-30) | 52(-9) | 57 | 61(7) | 70(23) |
| Heroin (caps) | 624(467) | 315(186) | 110 | 63(-43) | 53(-52) |
| Alcohol (drinks) | 45(-20) | 43(-23) | 56 | 59(5) | 55(-2) |
| Benzodiazepines (pills) | 87(-43) | 110(-28) | 152 | 207(36) | 200(32) |
| Cannabis (grams) | 87(1) | 60(-30) | 86 | 67(-22) | 68(-21) |
| Cocaine (caps) | 58(100) | 44(52) | 29 | 34(17) | 20(-31) |
| Pharmaceutical opioids (pills) | 30(-29) | 31(-26) | 42 | 56(33) | 61(45) |
| **Not heroin dependent (n=30)** | | | | | |
| Methamphetamine (points) | 62(-3) | 66(3) | 64 | 63(-2) | 66(3) |
| Heroin (caps) | 68(1600) | 29(625) | 4 | 3(-25) | 1(-75) |
| Alcohol (drinks) | 67(-22) | 71(-17) | 86 | 71(-17) | 65(-24) |
| Benzodiazepines (pills) | 12(-14) | 12(-14) | 14 | 12(-14) | 17(21) |
| Cannabis (grams) | 45(-10) | 41(-18) | 50 | 47(-6) | 45(-10) |
| Cocaine (caps) | 9(13) | 8(0) | 8 | 6(-25) | 7(-13) |
| Pharmaceutical opioids (pills) | 3(-77) | 4(-69) | 13 | 19(46) | 17(31) |

## DISCUSSION

The results of the current study can be summarised as follows:

- Demand for both methamphetamine and heroin was estimated to be relatively elastic (a 10% increase in methamphetamine price was estimated to result in a 18 - 19% decrease in the quantity of methamphetamine purchased and a corresponding increase in the price of heroin would lead to a 16% - 27% reduction in the quantity of heroin purchased);
- Own-price elasticity of demand for methamphetamine did not vary according to methamphetamine dependence but non-dependent heroin users were found to be significantly more responsive to own-price changes than dependent users. This greater responsiveness among non-dependent heroin users was largely attributed to the low baseline rates of heroin use among this group;
- Increases in the price of methamphetamine were estimated to lead to significant substitution into heroin (cross-price elasticity [CPE]=0.200 among dependent users and 0.054 among non-dependent users), pharmaceutical opioids (CPE=0.333 among dependent users) and cocaine (CPE=0.705 among non-dependent users). Substitution was of most concern in relation to heroin among methamphetamine dependent participants given the relatively low base rates of use of the other two drugs;
- No drugs were found to be significant complements for methamphetamine use (i.e. there were no significant falls in other drug use as the price of methamphetamine increased);
- Increases in the price of heroin were estimated to lead to significant substitution into methamphetamine (CPE=0.255 among dependent users), benzodiazepines (CPE=0.308 among dependent users) and pharmaceutical opioids (CPE=0.395 among dependent users and 0.764 among non-dependent users). Substitution was of most concern among heroin-dependent participants in relation to their use of methamphetamine and, in particular, their use of benzodiazepines;
- Cocaine was found to be a complement for heroin use among dependent heroin users (CPE=-0.538) but, again, off a relatively low base rate of use among this group.

In short, the results suggest that demand for both methamphetamine and heroin appears to be in the elastic range. We estimated that the own-price elasticities for these two drugs were greater than one, which suggests that any increase in the price of these drugs would result in a decrease in consumption and a decrease in overall expenditure on these drugs. However, there was also evidence of substitution into other drugs when the price of heroin and methamphetamine rose. This substitution must be viewed with concern. Here, it is important to acknowledge that these findings are specific to the study participants, who should not be taken as representative of methamphetamine users as a whole, and who operate in particular drug markets. Cocaine, for example, has limited availability outside of Sydney.

Weighing up the net effect of these price changes in light of this substitution is a difficult task. Because we were not interested in testing the income elasticity of demand, the study design involved giving participants a fixed budget and a variable amount of time in which to spend that budget. As a result, most participants spent their entire drug budget on each trial and overall expenditure varied little with drug prices. Based on the elasticity estimates and baseline purchases of the various drugs, we suspect that the overall decrease in heroin and methamphetamine purchases would outweigh the observed substitution into other drugs. When methamphetamine prices were varied, of most concern was substitution into heroin use among those who met the criteria for methamphetamine dependence. However, in response to a $10 increase in the price of methamphetamine from $50 (20 per cent) the estimated increase in heroin purchases from baseline would be in the order of two caps of heroin (from 56 caps) for the entire group, compared with a decrease of 30 points of methamphetamine (from 84 points).[11] For heroin dependent respondents, the biggest concerns were substitution into benzodiazepines and methamphetamine among heroin-dependent participants. Again, however, the analogous price increase from base rate, would translate into nine additional benzodiazepine pills (from 152 pills) and three extra points of methamphetamine (from 57 points). This compares with a decrease of 34 caps of heroin (from 110 caps).

The current findings support the findings of similar behavioural-economics studies and economic studies of secondary data that demand for an illicit drug is relatively elastic with respect to its own-price (e.g. Goudie et al. 2007; Grossman et al., 2002). They are also consistent with observations from the Australian heroin shortage that took hold around Christmas 2000. As the real price of heroin doubled in a short space of time, indicators of heroin use declined rapidly. While ethnographic research revealed that many primary heroin users supplemented their heroin use with methamphetamine while heroin supply was low (Maher et al., 2007), the supplementation does not appear to have been large enough to manifest itself in population-level data over the longer term (Snowball et al. 2008).

Like Saffer's and Chapoulka's (1999) study, we found complementarity between heroin, cocaine and cannabis, at least among the heroin dependent group. On the other hand, the current findings on cross-price responsiveness are not consistent with the only behavioural economics study to have explored poly-drug use involving amphetamines. While Sumnall et al. (2004) established that demand for amphetamine was relatively elastic, increases in the price of amphetamine were found to have no impact on purchases of cocaine and ecstasy although they did result in some substitution into alcohol. These discrepant findings are likely to be a function of the populations of drug users sampled. Sumnall et al. (2004) investigated a younger group of drug users that reported a preference for ecstasy, whereas the current study focused on a comparatively older population of drug users, of which a significant portion regarded heroin or methamphetamine as their drug of choice. Furthermore, in the United Kingdom, there is some evidence that amphetamine use is decreasing amongst poly-drug users (Sumnall et al. 2004), whereas in Australia, as reviewed in the introduction, methamphetamines remain one of the most commonly used illicit drugs.

Based as they are on hypothetical drug purchases, the applicability of the results depends on the degree to which stated preferences would translate into actual behaviour. However, there are prima facie reasons to have confidence that people would behave in the way they say they would. We followed a well-respected experimental approach. The scenario conditions were defined so that they reflected real-world drug markets as closely as possible. The fixed income was set at a level that approximated weekly levels of income support – on which most people in the sample received as their primary source of income – and drug prices were set at the median levels estimated from sentinel groups of illicit drug users such as the sample obtained here. The range of methamphetamine prices was also consistent with the range reported among illicit drug users in the Sydney market (Phillips and Burns 2009). Ajzen and Fishbein (1980) proposed in their often-cited 'theory of reasoned action' framework that, in such circumstances, people's behavioural intentions usually closely reflect their behaviour. Indeed, a good example of the close alignment of intention and behaviour can be found from observing electoral opinion polls. If conducted with methodological rigour, telephone polls usually very closely predict electoral outcomes. Nevertheless, that there is a close association between intentions and behaviour remains an assumption of the methodology employed here that we are not able to test.

While every effort was made to ensure that the scenarios reflected real-world drug market characteristics, the complex characteristics of real world drug-markets cannot be perfectly simulated in an experimental setting. The experimental design provided respondents with a fixed budget, which is often not the case in reality. Income can vary depending on availability of legitimate employment or through willingness to commit criminal activity to raise income to purchase illicit drugs. While the majority of the respondents were reliant on a fixed income – income support – a notable proportion received most of their income from criminal activity or sex work, which are more flexible income flows. As the price of a drug increases, one real world response would be to undertake more crime (although there is, of course, an upper limit to the amount of crime or sex work one person can do).

A further limitation of the current findings is that we did not attempt to obtain a representative sample of methamphetamine users, nor did we make any attempt to control for the characteristics of our sample other than their level of dependence. While we cannot, therefore, generalise the results of the current study to all methamphetamine users, it was not our intention to do so here. Our primary aim was to determine how responsive sentinel groups of frequent methamphetamine users might be to changes in its price and that of heroin. Nevertheless, it is possible that other groups of methamphetamine users might respond differently than the group studied here.

Perhaps the most critical limitation of the approach used here was that illicit drug market adjustments are more likely to manifest as changes in the purity and/or quantity of drug sold for a given price (Caulkins 2007). Concerned about the difficulties associated with varying quality in an experimental setting we, in a sense, proxy such quality changes as price changes. Again we impressed upon the respondents the need to assume that quality, purity and quantity were constant over the life of the experiment. However, some respondents were reluctant to buy methamphetamine when its price was $10 on the basis that this price would normally be associated with poor quality product. Gaining an understanding of the complex interplay between drug price, drug purity and drug consumption should be at the forefront of future attempts to understand consumer responsiveness to changes in drug market characteristics.

## CONCLUSION

In summary, the current study found that, for this group of methamphetamine users, consumption of heroin and methamphetamine fell substantially in response to increases in their price. While there was evidence of substitution into other drugs, this substitution proved nowhere near large enough to offset the reductions in methamphetamine and heroin use. In determining the net effect on drug use this analysis illustrates the importance of distinguishing between the behavioural responses of those dependent on the drug in question and those who are not dependent, and taking account of the rates of drug use prior to any price change. These findings lend support to one of the primary levers by which supply side drug law enforcement policy aims to limit drug-related harm, which is to put upward pressure on drug prices and, in turn, downward pressure on drug consumption.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## NOTES

1. Drug Policy Modelling Program, National Drug and Alcohol Research Centre, UNSW
2. NSW Bureau of Crime Statistics and Research
3. In this paper methamphetamine includes amphetamine and methamphetamine but excludes ecstasy.
4. However, purchases of heroin were independent of changes in the price of valium, a finding later confirmed by Petry (2001) in a study examining drug use among alcoholics.
5. Behavioural economic analyses and economic analyses have both found that purchases of a drug are contingent on available income (e.g. Petry and Bickel 1998; Bretteville-Jensen 2006) and income elasticity of demand was not the focus of this study.
6. One tablet represented 100mg of morphine and 80mg of oxycodone.
7. Count data is typically analysed with a Poisson regression model where the expected hypothetical units purchased is modelled as a function of the explanatory variables. However, the Poisson model makes the strong assumption that the expected count (mean of units purchased) is identical to its variance. Often, as was the case here, the variance exceeds the mean and the negative binomial model is more appropriate since, by allowing for heteroskedasticity, the variance can differ from the mean (Greene 2008; Kennedy 2008). However, the standard negative binomial model was also found to provide a poor fit to the data here due the large number of zero counts. Zero-inflated regression models (poisson and negative binomial) were adopted to account for the high number of zero responses. The zero-inflated models differentiate between two groups of respondents - those who would not purchase the drug at any price and those who would be willing to purchase the drug at some price (Greene 2008, pp.922-924).
8. The Friedman two-way analysis of variance by ranks test was applied to determine whether the median of the six groupings of hypothetical purchases was equal for all prices (all participants, methamphetamine dependent and not methamphetamine dependent vis-à-vis methamphetamine price and all participants, heroin dependent and not heroin dependent vis-à-vis heroin price) (Siegel and Castellan, 1988). The tests indicated that in each of the groupings there was a significant difference between the median purchases for at least two of the prices at the 1 per cent level of significance. The Page test, a distribution free rank-test for ordered alternatives suitable for repeated measure data, was then used to determine whether price was inversely related to hypothetical purchases (Siegel and Castellan, 1988). For each grouping the Page test suggests that there is a statistically significant inverse relationship between purchases and the relevant price; at the one per cent level of significance for the three groupings pertaining to methamphetamine price, at the one percent level for all participants and heroin dependent participants in relation to heroin price, but only at the five per cent level for non-heroin dependent participants in relation to heroin price.
9. The Friedman tests revealed that purchases of cannabis and pharmaceutical opioids were significantly related to the heroin price at the one per cent level in both groups. In the dependent group, so too were cocaine purchases. Methamphetamine and benzodiazepine purchases also showed a significant relationship at the five per cent level. In the non-dependent group alcohol was significantly related to price at the five per-cent level. Visual observation

suggests that there is substitution into pharmaceutical opioids in both groups with the dependent group also substituting into methamphetamine and benzodiazepines. Members of this group also appear to purchase cocaine with heroin. Page tests revealed that when all participants were considered there was a significant inverse relationship between the heroin price and cocaine at the 10 per cent level and significant positive relationships between heroin price and both methamphetamine and pharmaceutical opioids at the five per cent and one per cent levels respectively. However, when grouped by level of dependence only the relationship between heroin price and methamphetamine in the dependent group maintained significance.

10. We thank our anonymous reviewer for bringing this to our attention.

11. These estimates are based on the elasticities shown in Table 2.

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