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Australia's Ice Crisis and the Detrimental Mental Health Effects of Recent Use

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Abstract

This work applies propensity score matching to assess the impact of methamphetamine on mental health. Using Australian microdata from the 2012 National Drug Strategy Household Survey, *Kessler scores* of recent and non-recent methamphetamine users are analysed after controlling for confounding variables. The results support the decision to prepare frontline emergency service workers for the psychological issues present in those consuming methamphetamine. The results also highlight the importance for policy makers to develop effective harm reduction programs. An estimate of the mental health costs associated with methamphetamine abuse is also presented, the findings of which strongly support additional government spending on harm reduction.

JEL codes: I12, I18, K42.

Keywords: harm reduction, mental health, methamphetamine, propensity score matching.

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1. Introduction

Crystal methamphetamine ('ice') is an illegal recreational drug that has become widely available in Australia. Due to its prevalence, addictive qualities and the severity of side effects, the abuse of ice is regarded as a serious social problem. Crystal methamphetamine remains a relatively under-researched drug, meaning policy decisions that are required today lack informed decision making. By way of quantitative analysis, this paper seeks to provide useful information for researchers and policy makers designing strategies aimed at understanding and reducing methamphetamine-related harm.

The 2013 *National Drug Strategy Household Survey* (Australian Institute of Health and Welfare, 2014) indicates that users of methamphetamine are shifting consumption preferences to a much more potent, crystallised form of the drug, ice. Given the limitations surrounding household surveys (a likely underrepresentation of illicit substance users), several researchers have sought to better understand methamphetamine usage in Australia through analysis of illicit drug-related hospital admissions and local wastewater analysis. Findings from this research suggest that methamphetamine consumption has rapidly increased in recent years.

The rising use of ice in Australia is worrisome. The enhanced purity of ice leads to a strong risk of dependency with rehabilitation efforts currently showing limited signs of success. Users are subject to serious short- and long-term negative physical and mental health effects, including sudden death. For the wider community, the most concerning aspect of ice abuse is the tendency for the drug to induce psychosis and unpredictable outbursts of physical violence - particularly at a time when mental health and domestic abuse is at the forefront of Australian Government policy.

Amphetamine-type (including methamphetamine) arrests in Australia are on the rise, and an increasing portion of detainees are testing positive for methamphetamine in drug tests. Paramedics and police officers are increasingly being confronted with ice abuse related aggression, prompting the government to deliver tailored training packages to protect frontline workers.

Studies on the side effects of methamphetamine have found the drug to be highly correlated with poor mental health, including severe anxiety and clinical depression. Unlike other illicit substances, pharmacotherapies to treat methamphetamine withdrawal and prevent relapse have not been found to be effective. The purpose of this work is to quantify the detrimental relationship between recent methamphetamine consumption and psychological wellbeing; using Australian household data. Finding a causal link between methamphetamine

use and negative mental health outcomes may discourage use of the drug amongst those considering taking up the drug for the first time, particularly young Australians.

We estimate the effect that recent use of methamphetamine has on an individual's mental health using data drawn from the *National Drug Strategy Household Survey*. Propensity score matching is employed to estimate the difference in mental health scores between recent and non-recent methamphetamine users after controlling for confounding explanatory variables.

Mental health scores are measured using the *Kessler Score*, a globally recognised measure of psychological distress on a scale of ten to fifty; ten being perfect mental health. The estimated mean difference in Kessler scores across various propensity score matching techniques is 2 units; 5% of the gap between the maximum and minimum score. The 2 unit increase in Kessler score moves recent users from the 'low' to the 'moderate' classification range for levels of psychological distress.

Our analysis indicates that underlying psychological issues are present in both recent and non-recent users not attributable to methamphetamine, highlighting the need for tailored psychiatric care during rehabilitation. A simple estimate of methamphetamine-related mental health expenditure in Australia based on national costs published by Medibank (2013) suggests a national cost of \$198 million annually in 2017 Australian dollars. The results and cost estimates are likely to be conservative, given that individuals with severe psychological distress symptoms warranting primary treatment or hospitalisation were excluded from the scope of the *National Drug Strategy Household Survey*, as were the homeless and incarcerated. Nevertheless, our cost estimate strongly supports additional government spending on harm reduction.

Our paper is the first to apply propensity score matching to Australian microdata to quantify the effect of recent methamphetamine consumption on mental health scores. Several surveys have been conducted overseas that aim to understand the impact of methamphetamine on subjective mental health. To the knowledge of the authors, at the time of writing, no such analysis has been completed in Australia.

2. The economic and social characteristics of ice

2.1 Background

Methamphetamine is a synthetically-produced central nervous system stimulant. Varying methods of production result in the final product being supplied in paste, powder, tablet or crystal form ('ice'). Simplicity of production, enhanced purity and a reduction in

street value has fuelled popularity of the crystalized form of the drug over paste and powder alternatives, causing significant increases in both supply and demand (Department of the Prime Minister and Cabinet, 2015a). The fall in the relative price of crystal methamphetamine is particularly concerning as individuals are substituting out of relatively less harmful drugs into crystal methamphetamine; and those already using methamphetamines are shifting to a more potent form of the drug.

Methamphetamine abuse is not a concern limited to Australia. Global quantities of amphetamine-type stimulants (ATS) seizures more than doubled from 93 tonnes in 2010 to 191 tonnes in 2015, with methamphetamine accounting for 61-80 % of annual seizures. East and South-East Asia and Oceania were the main recipients of trafficked methamphetamine, with the Middle East, South-West Asia and Western and Central Europe primarily acting as transit points. Seizures were highest in East and South-East Asia, closely followed by North America. National experts deemed methamphetamine to be the most used drug in China, Japan, the Philippines and Singapore (United Nations Office on Drugs and Crime, 2017). Methamphetamine was identified by law enforcement agencies as the second greatest drug threat in America behind heroin (U.S. Department of Justice, 2017). This paper considers methamphetamine use in Australia only.

2.2 Prevalence and consumption habits

According to the 2013 *National Drug Strategy Household Survey* (NDSHS), 1.3 million people have used methamphetamine in their lifetime, approximately 400,000 of those in the previous twelve months of the survey period. Among recent users, the use of the crystallised form of methamphetamine (ice) had more than doubled since 2010 from 22% to 46% in 2013. Methamphetamine users opting to use ice were far more likely to consume on a regular basis (25%), corroborating the medical industry's observations on the drug's addictiveness (Heller, 2015, McKellar, 2005).

Employing methods widely applied in research to estimate relatively hidden or stigmatised patterns of illicit drug use, Degenhardt *et al.* (2016) estimate that in 2013/14 there were 268,000 *regular* methamphetamine users in Australia and 160,000 *dependent* users aged 15-54 years. Their findings indicate almost a tripling of regular users and doubling of dependent users since 2009/10. These results could be overestimated as hospital admissions

(the multiplier in prevalence estimations) are increasing in part due to the increasing potency of the drug, rather than a nominal increase in users.¹

Lai *et al.* (2016) examined Australian trends in methamphetamine residues in wastewater. Results indicated that between 2009 and 2015 consumption increased 4.8 times in metropolitan areas (based on 498 samples) and 3.4 times in regional cities (based on 712 samples). However, a limitation to this study was that the findings were not adjusted for the increase in purity of methamphetamine over the same time period.² In 2016 the federal government allocated \$3.6 million in funding towards the National Wastewater Drug Monitoring Program, aimed at providing an accurate insight into the extent of drug abuse in Australia (Moor, 2016).

2.3 Crime

Law enforcement has struggled to contain the rising levels of ice consumption. The Australian Customs and Border Protection Services reported seizing close to three and a half tonnes of ATS at the border in 2014/15, with crystal methamphetamine being the overwhelming majority (76%). Crystal methamphetamine detections increased by an astonishing 59% between 2012/13 and 2014/15 (Australian Customs and Border Protection Services, 2015).

The Australian Criminal Intelligence Commission reports that 667 clandestine laboratories were detected by police in 2014/15, with just over half of those confirmed as being used for the production of amphetamine (2016). Whilst this figure is down from the previous year (744), detections have increased 70% over a decade. ATS-related arrests were at an all-time high in 2014/15 with 35,463 arrests nationally, 35% higher than the previous year (Australian Criminal Intelligence Commission, 2016).

Anecdotal evidence suggests that ice is responsible for rising crime rates as those dependent on the drug turn to theft as a means of supporting their addiction (Lowrey and Poole, 2015; Roberts, 2016). In 2014, 2,310 adult detainees were interviewed regarding methamphetamine consumption habits. An alarming 48% of detainees reported using methamphetamine in the previous twelve months; a further 18% reported using methamphetamine in the 48 hours prior to their arrest. Of 790 urine samples taken from the

¹ An increase in potency (therefore harm) is likely to lead to an increase in hospital admissions per methamphetamine user; not necessarily an increase in the number of users.

² An increase in potency would lead to an increase in methamphetamine residue in wastewater, leading researchers to conclude that consumption and or number of users has risen; whereas it is possible that the number of users has remained stable, and the potency of methamphetamine per 'hit' has increased. Lai *et al.* (2016) note this limitation.

detainees, 37% tested positive to methamphetamine (Australian Institute of Criminology, 2014). This is the highest percentage ever recorded by the *Drug Use Monitoring in Australia* program, up from 16.4% positive tests in 2009 (Australian Institute of Criminology, 2009).

2.4 Relative harm

Like other nations, Australia has struggled with illicit drugs in the past, notably opium, ecstasy and heroin. The motivation for ice becoming a modern-day concern stems from the drug's purity, method of intake, addictiveness and destructive psychoactive effects. When ice is injected or smoked, the effects of the drug are felt faster and are intensified (Cook *et al.*, 1993); since these routes of administration bypass the body's defences and detoxifying organs. Using illicit drugs in this manner is shown to increase dependency (Gossop *et al.*, 1992; Novak and Kral, 2011). Other risks include the spreading of disease through needle sharing (Todd *et al.*, 2015) and heightened risk of overdose (Gossop and Griffiths, 1996).

Ice is the most potent form of methamphetamine, which translates to an increased likelihood of addiction and greater harm (McKetin and Black, 2014; NSW Ministry of Health, 2016). The *National Ice Taskforce* reports that the purity of seized ice and other forms of methamphetamine has increased from a national median of 7% in 2010/11 to 62% in 2013/14. By comparison, cocaine's median purity is reported as 40% and heroin's as 17% (Department of the Prime Minister and Cabinet, 2015a).

For the wider community the most concerning aspect of ice is its tendency to induce violent psychosis in the user. The drug is known to stimulate the release of noradrenaline (McKetin and Black, 2014) a neurotransmitter capable of triggering the 'flight or fight' reaction. When paired with anxiety and paranoia, users often display irrational bouts of aggression (Boles and Miotto, 2003; Payer *et al.*, 2011). Tests conducted by Crowley (1971) and Sokolov *et al.* (2004) found doses of methamphetamine to significantly increase aggressive behaviour amongst rats. More recently, McKetin *et al.* (2014) established a causal link between methamphetamine and violent behaviour. Controlling for pre-existing tendencies, researchers found that 10% of users were violent when not using the drug, whilst 60% were violent when they used the drug heavily. The Australian Institute of Criminology's drug use monitoring report found amphetamine present in 31% of detainees arrested for violence-related acts in 2013/14. By comparison, only 1% of detainees were detected with cocaine, 13% with opiates and 22% with benzodiazepines.

Australian frontline emergency workers are repeatedly confronted with ice-related violence (Strokes, 2015; Willacy, 2015). Drug-related ambulance callouts rose 27% in rural and 10% in metropolitan Victoria between 2012/13 and 2013/14 (Turning Point, 2015). In response, the Victorian Government delivered a tailored training package, *Ice: Training for Frontline Workers* (NCETA, 2018).

Whilst addiction to heroin is treatable by way of methadone, pharmacotherapies to treat methamphetamine withdrawal and prevent relapse have not been found to be effective (Jenner & Lee, 2008; National Institute on Drug Abuse, 2013). Residential rehabilitation *may* produce a time-limited decrease in methamphetamine use (McKetin *et al.*, 2012).

2.5 Impact on mental health

Sommers *et al.* (2005) analysed the results of a questionnaire that surveyed 106 individuals in Los Angeles County who had used methamphetamine for a minimum of three months. The results strongly suggested that methamphetamine had negative consequences on mental health. Thirty-six per cent of respondents reported depression, 62.3% paranoia and 37.7% hallucinations. Respondents were ranked on a psychological problem index ranging from 1-5, with 1 representing good mental health and 5 representing severe psychological problems. Casual users of methamphetamine averaged a score of 2.25 whilst daily users averaged 3.60. These findings do not account for other demographic variables that may influence mental health scores, potentially overstating the psychological effect of methamphetamine.

Plüddemann *et al.* (2010) conducted studies on the effect of methamphetamine on mental health and depression amongst high-school students in South Africa. The cross-sectional survey of 15 randomly selected schools contained a sample size of 1,561 males and females with a mean age of fifteen. Nine per cent of the sample had tried methamphetamine at least once. Ordinal logistic regression analysis, which accounts for confounding variables, showed that methamphetamine was significantly associated with both higher mental health risk scores and depression scores. Students who had used methamphetamine recently (or more regularly) were shown to be at greatest risk for potential mental health problems and higher levels of aggressive behaviour.

Looby and Earleywine (2007) found a clear covariance between methamphetamine and psychological wellbeing via analysis of results from an internet-based survey. Their sample consisted of 610 ice users and 6,063 non-users. After conducting an econometric analysis

accounting for confounding variables including age, gender and consumption of other drugs, methamphetamine accounted for significant variance in depression, apathy, life satisfaction, happiness and subjective wellbeing.

Glaser-Edwards *et al.* (2009) analysed the reduction in depressive symptoms amongst methamphetamine users that had undergone treatment to reduce consumption. Participants were assessed for depression, substance use, and psychosocial outcomes at three time periods - baseline, treatment discharge, and three-year follow-up. A multivariate regression model controlling for demographics, frequency of use and route of administration revealed that the reduction in depressive symptoms was significantly greater for those who abstained compared to those who used methamphetamine. Overall, 15.2% of the sample at three-year follow-up met major depressive disorder criteria. A significantly greater proportion of those who reported using methamphetamine during the month preceding follow up were diagnosed with major depressive disorder (25.9%) relative to those who were abstinent (10.6%). In addition, it was found that depression scores were significantly related to route of administration; injectors reported more depressive symptoms than those who used other routes.

3 Methodology

3.1 Propensity score matching

We apply observational data from the 2013 NDSHS to estimate the effect of a treatment, methamphetamine, on mental health. This is done by drawing a sample of methamphetamine users and examining the mental health scores between those who used the drug recently (<12 months) and at some stage in their lifetime (>12 months). Simply taking the difference in mental health scores between those treated (recent methamphetamine users) and non-treated (non-recent methamphetamine users) would be problematic, since there are many other demographic traits affecting a person's mental health besides their decision to use or not use methamphetamine. It is crucial that the systematic differences in baseline characteristics between treated and untreated subjects are accounted for when estimating the effect of methamphetamine on outcomes.

Propensity score matching (PSM) is a statistical matching technique developed by Rosenbaum and Rubin (1983) that allows researchers to obtain estimates on binary treatments from observational data. A defining characteristic of the approach is the ability of the model to overcome confounding variables and isolate causality, something researchers have long struggled to achieve. In addition, PSM can reduce selection bias that is commonly present in

non-experimental data, i.e., when observations cannot be randomly assigned to a particular treatment, and those observations that are treated are systematically different from those that are not. Selection bias and causal inference are removed by employing a predicted probability, or *propensity*, of treatment likelihood, rather than normal matchmaking on single characteristics.

Propensity score matching requires a binary treatment, arbitrary characteristics presumed to be confounding variables and an output variable of interest. Suppose T represents a binary treatment taking the value of 0 or 1, in this case;

$$\begin{aligned} \text{non-recent methamphetamine user} &= 0 \\ \text{recent (< 12m) methamphetamine user} &= 1 \end{aligned}$$

Confounding variables, X , chosen for this study are the demographic traits sex, age, age², household status, marital status, highest level of education attained, annual income and geographic location. Additional or alternative characteristics could be chosen but this study is limited by the breadth of data in the *National Drug Strategy Household Survey*. Y , the output variable of interest, is the *Kessler score*; the internationally recognised measure of distress based on questions about anxiety and depressive symptoms.³ Propensity score, p , is the conditional probability of a treatment given background variables noted as:

$$p(x) \stackrel{\text{def}}{=} \Pr(T = 1|X = x)$$

Let $Y(0)$ and $Y(1)$ be the average Kessler outcomes for non-recent users and recent users. Treatment assignment is then unconfounded if potential outcomes are independent of treatment conditional on background variables, X :

$$Y(0), Y(1) \perp\!\!\!\perp T|X$$

where $\perp\!\!\!\perp$ denotes statistical independence. If unconfoundedness holds, then:

$$Y(0), Y(1), \perp\!\!\!\perp T|p(X)$$

and the estimated Kessler score of non-ice users and ice users is statistically independent from confounding variables, X . Analysis of the difference in Kessler score between matched recent users and non-recent users now allows the researcher to estimate the effect of methamphetamine on mental health, stripped from confounding variables that would otherwise influence the outcome.

³ This is a 10-item questionnaire intended to yield a global measure of distress based on questions about anxiety and depressive symptoms that a person has experienced in the most recent 4-week period. Responses are measured on a Likert scale ('none of the time = 1' to 'all of the time = 5') with the totalled final score measured on a scale of 10 (no mental disorder present) to 50 (severe mental disorder present) (Kessler *et al.*, 2002).

3.2 Estimating the propensity score

A probit regression is formulated comprising the binary treatment (T), appropriately chosen confounders (X) and output variables of interest (Y). The probit regression estimates the probability of a person taking up methamphetamine conditional on confounding variables. Recent users and non-recent users are then matched according to similarities in their covariate distributions allowing a comparison across similar observations.

3.3 Experimentation with different matching algorithms

Matched observations should possess the same propensity to have consumed methamphetamine within twelve months prior to the survey. Achieving such matches can prove difficult when data are limited or when traits between groups are so different that finding a match is impossible. There are several different matching techniques available for refining matches, we apply radius matching, nearest neighbour matching and kernel matching.

Radius matching, also known as caliper matching, sets a maximum radius around an observed methamphetamine user in which a non-recent user can be matched based on background variables. The width, or radius, can be adjusted to either expand or contract the search for a match. The tighter the restriction on the radius, the closer the match and the more reliable the output results. However, this comes at the expense of the number of matches created.

Nearest neighbour matching (NNM) uses distance between covariate patterns to match observations with the closest propensity score. NNM can be altered to allow for more than one untreated observation to be matched with a treated observation. Choosing multiple neighbours decreases bias but increases standard errors due to the smaller sample size caused by a more stringent specification.

Kernel matching matches each treated observation with a weighted average for the matched non-treated. The weights are based on the distance between the covariates of the two groups with greater weighting given to those closest to the treated (Kaplan, 2014). It is paramount that the matching techniques be tested over multiple levels of restriction. Each technique will provide varying output results. If the variable coefficients remain similar and significant over a range of restrictions, this is an indication that the results are more reliable.

3.4 Balance in the characteristics of the treatment and comparison groups

For reliable output results characteristics between the matched observations should not be significantly different. This is checked by a t-test based on a regression of the background variables on a treatment indicator to test the equality of the means in the matched samples. Whilst the matching process may have been successful, the means between groups need to be statistically similar for the output results to be accepted.

Outputs of the t-test include a standardised percentage bias: the percentage difference of the sample means in the treated and non-treated sub-samples as a percentage of the square root of the average of the sample variances in the treated and non-treated groups (Rosenbaum and Rubin, 1985). The percentage bias should not be too far in favour of one group over the other. Outputs also include Rubin's 'B', the absolute standardized difference of the means of the linear index of the propensity score in the treated and non-treated group, and Rubin's 'R', the ratio of treated to non-treated variances of the propensity score index. Rubin (2001) recommends that 'B' is less than 25 and that 'R' is between 0.5 and 2 for the samples to be considered sufficiently balanced (Leuven and Franceschi 2016)

Ideally, for each propensity score there would be an equal amount of treated and untreated observations matched. In the case of small sample sizes, this may prove difficult. Matches will become particularly difficult at higher propensities when the characteristics of the treated are exceedingly different to those untreated.

3.2.4 Estimating the effect of the treatment

When analysing the differences in treatment effects, two approaches are commonly taken. The *average treatment effect* (ATE), $E[Y_i(1) - Y_i(0)]$, provides the average effect, at the population level, of moving an entire population from untreated to treated. The *average treatment effect of the treated* (ATT), $E[Y(1) - Y(0)|T = 1]$, explains the average effect of treatment on those subjects who ultimately received the treatment (Grilli and Rampichini, 2011). Since the goal here is to find a link between the treatment (recent use of methamphetamine) and mental health, the ATT is of most significance.

In order to not reject the hypothesis that consumption of methamphetamine has a negative impact on mental health, the average treatment effect must be positive. Given that the Kessler score ranges from 10 to 50, with 50 indicating very high levels of psychological distress, a positive average treatment effect indicates that methamphetamine consumption is having detrimental effects on mental health.

4. Data and variables

4.1 Data source

The 2013 NDSHS collected data from 23,855 people across Australia's residential population aged 12 years or older. Households are selected by a multistage, stratified area random sample design. Whilst the sample is unbiased and randomised, the nature of a household survey means that those who are homeless, or happen to be incarcerated or in residential care at the time, are excluded from the survey. The survey has been criticised for being heavily distributed around major cities. However, with respect to the resources required for its distribution, the survey still managed to garner responses from 3,786 Australians living remotely. Further, the NDSHS is the most comprehensive dataset available for this research task. Despite this, we acknowledge that results are most likely conservative due to exclusions in the initial sampling method and possible reluctance of participants to answer personal questions with honesty. Respondents above the age of 79 were excluded from the sample prior to applying PSM in order to achieve greater balance in the characteristics of the treatment and comparison groups. After excluding respondents above the age of 79, 22,698 survey responses remained.

4.2 Variable description

4.2.1 Treatment variable - methamphetamine user

Out of 23,564 respondents, 1,973 indicated that they had consumed meth/amphetamine at some time in their lifetime (8.37%) - see Table 1. Persons aged 20-39 were most likely to indicate that they had consumed methamphetamine at some stage in their lifetime, and consumption is slightly more prevalent amongst males - see Table 2. Three-hundred and forty-seven methamphetamine users recorded their preferred form of the drug, with the large majority selecting crystals (45.82%) - see Table 3.

Table 1: Ever used methamphetamine

	Freq.	Per cent	Cum.
Yes	1,973	8.37	8.37
No	21,591	91.63	100
Total	23,564	100	

Table 2: Ever used methamphetamine by age and gender

Age	Male		Female	
	Yes	No	Yes	No
12-19	18	764	19	779
20-29	222	994	227	1,417
30-39	342	1,278	351	2,043
40-49	210	1,481	241	1,978
50-59	115	1,574	99	2,047
60-69	32	1,858	43	2,089
70-79	17	1,029	20	1,152
80+	10	542	7	576
Total	966	9,520	1,007	12,071
Total (%)	9%	91%	8%	12%

Table 3: Preferred form of methamphetamine

	Freq.	Percent	Cum.
Powder	117	33.72	33.72
Liquid	3	0.89	34.58
Crystal (<i>ice</i>)	150	45.82	80.40
Base/Paste/Pure	23	6.63	87.03
Tablet	26	7.49	94.52
Prescription amphetamine for non-medical purposes	9	2.59	97.12
Capsules	10	2.88	100
Total	347	100	

Methamphetamine use in the 12 months leading up to the survey is of most interest when analysing the effect of the drug on mental health. The effect will be observed by the largest magnitude when consumption is recent. Of 1,973 individuals who had consumed methamphetamine at some stage in their lifetime, 1,499 revealed their time of consumption – see Table 4. Four-hundred and twenty-five (29.33%) indicated that they had consumed methamphetamine within the previous twelve months of the survey. Methamphetamine users that indicated they had consumed the drug within the past twelve months represent 1.78% of the entire survey population.⁴ Recent consumption of methamphetamine is most prevalent in the 20 to 29 age bracket, and males are more likely to have consumed recently than females – see Table 5.

⁴ On the assumption that 29.33% is a representative figure, 139 of the 474 methamphetamine users who did not provide their time of last consumption could be assumed to also be recent users. Under these assumptions, recent methamphetamine users would represent 2.36% of the entire survey population.

Table 4: Used methamphetamine in the past 12 months

	Freq.	Per cent	Cum.
Yes	425	29.33	29.33
No	1,024	70.67	100
Total	1,449	100	

Table 5: Used methamphetamine in the past 12 months by age and gender

Age	Male		Female	
	Yes	No	Yes	No
12-19	12	2	9	5
20-29	89	101	84	103
30-39	74	203	53	222
40-49	49	118	26	133
50-59	18	62	8	46
60-69	2	9	0	14
70-79	1	3	0	2
80+	0	1	0	0
Total	245	499	190	525
Total (%)	33%	67%	26%	74%

4.2.2 Output variable - Kessler score

The NDSHS asks ten behavioural questions related to mental health and stability, known in the medical industry as the ‘Kessler Psychological Distress Scale’. Kessler and Mroczek (1992) developed the scale as a global measure of distress, anxiety and depression. Respondents are asked intimate behavioural questions recorded on a 5-point Likert scale. Levels of psychological distress are categorised by the Australian Institute of Health and Welfare into four ranks (K10 RANK) that are shown in Table 6.

Table 6: K10 score distribution

Kessler Score	K10RANK (1-5)	Level of Psychological Distress	K_STAR	Freq.	Per cent	Cum.
10-15	1	Low	12.5 [Low]	16,383	69.3%	69.3%
16-21	2	Moderate	18.5 [Moderate]	4,824	20.4%	89.7%
22-29	3	High	25.5 [High]	1,754	7.4%	97.1%
30-50	4	Very High	40 [Very High]	680	2.9%	100.0%

By default, the ranking utilised in the NDSHS is not ordinal. To estimate the magnitude of effect on a scale comparable to the traditional Kessler Scale (10-50), variable K10RANK is replaced by the midpoint of each Kessler score band. Thus, the new K10RANK (K_STAR) is

constructed from an initial continuous variable as a method of partially recovering the original continuous variable.⁵

The Kessler test was completed by 23,641 people. The majority of respondents (69.3%) present a healthy mental health score; 20.4%, 7.4% and 2.9% of respondents present a moderate, high and very high level of psychological distress. The mean Kessler score of the entire sample is 15.48 and the standard deviation is 5.72 units.

4.2.3 Explanatory variables

Explanatory variables included in the analysis are sex, age, marital status, household status, education, combined household income, and Australian Statistical Geography Standard: see Table 7.

5. Results

5.1 Caliper matching

Caliper matching showed a statistically significant difference between Kessler score of those treated and non-treated. The matching process was able to match 236 to 242 recent methamphetamine users with 778 non-recent methamphetamine users that possessed similar characteristics. A matching test concludes that all caliper widths besides 0.5 satisfy the matching criteria (Mean Bias <5%, Median Bias <5%, Rubin's B $0 < B < 25$, Rubin's R $0.5 < R < 2.0$).

Table 8 presents the matches for caliper width 0.05. Matches were found at all propensity scores besides the upper quarter. The background traits of the treated at this propensity level (>0.75) could not be matched with the non-treated.

Taking the average of the ATT scores across each caliper width that satisfies the matching criteria provides an estimated ATT of 1.969. An individual that has consumed methamphetamine within the last twelve months is likely to record a Kessler score 2.0 units (rounded) higher than someone with similar demographic traits who did not.

⁵ Due to incomplete questionnaire responses (i.e., only 9 out of 10 Kessler questions answered) an exact Kessler score for each respondent could not be calculated from the NDSHS data. Instead we adopt the variable K10RANK. Derived by the AIHW, K10RANK overcomes the incomplete information issue to provide a consistent measurement for Kessler score.

Table 7: Explanatory variables

Variable	Freq.	Percent	Cum.
Sex			
Male	10,624	44.5%	44.5%
Female	13,231	55.5%	100.0%
Total	23,855		
Marital Status			
Never married	4,862	20.9%	20.9%
Widowed	1,499	6.4%	27.4%
Divorced	1,933	8.3%	35.7%
Separated but not divorced	757	3.3%	38.9%
Married (inc. de facto)	14,205	61.1%	100.0%
Total	23,256		
Household Status			
Person Living Alone	3,863	16.4%	16.4%
Couple Living Alone	6,218	26.4%	42.7%
Couple with Non-Dependent Child	1,998	8.5%	51.1%
Couple with Dependent Child	6,553	27.9%	79.2%
Couple with Dependent and Non-Dependent Children	905	3.8%	83.1%
Sing Parent with Non-Dependent Child	486	2.1%	85.1%
Single Parent with Dependent and Non-Dependent Children	1,315	5.6%	90.7%
Non-related Adults Sharing house/apartment/flat	887	3.8%	94.5%
Other Household Type	1,299	5.5%	100.0%
Total	23,518		
Education			
Certificate I or Certificate II	1,877	13.5%	13.5%
Certificate III or Certificate IV	3,740	26.6%	40.1%
Associate Diploma	2,766	12.1%	52.2%
Undergraduate Diploma	1,209	5.0%	57.2%
Bachelor Degree	3,554	25.3%	82.5%
Master's Degree, Postgraduate Degree	2,196	15.6%	98.1%
Doctorate	263	1.9%	100.0%
Total	14,059		
Combined Household Income			
\$145,600 or more (\$2,800 or more/ week)	3,740	18.9%	18.9%
\$104,000 - \$145,599 (\$2,000 - \$2,799 /week)	2,553	12.9%	31.8%
\$83,200 - \$103,999 (\$1,600 - \$1,999 /week)	2,120	10.7%	42.5%
\$67,600 - \$83,199 (\$1,300 - \$1,599 /week)	1,844	9.3%	51.8%
\$52,000 - \$67,599 (\$1,000 - \$1,299 /week)	1,417	7.2%	59.0%
\$41,600 - \$51,999 (\$800 - \$999 /week)	1,219	6.2%	65.1%
\$31,200 - \$41,599 (\$600 - \$799 /week)	1,369	6.9%	72.0%
\$20,800 - \$31,199 (\$400 - \$599 /week)	1,290	6.5%	78.5%
\$13,000 - \$20,799 (\$250 - \$799 /week)	403	2.0%	80.6%
\$7,800 - \$12,999 (\$150 - \$249 /week)	73	0.4%	81.0%
\$1 - \$7,799 (\$1 - \$149 /week)	132	0.7%	81.6%
Nil Income	419	2.1%	83.7%
Negative Income	89	0.4%	84.2%
Prefer not to say	3,131	15.8%	100.0%
Total	19,799		
Australian Statistical Geography Standard (ASGS3)			
Major City	15,926	67%	67%
Inner Regional/Inner Suburb	4,143	17%	84%
Outer Regional/Remote/Very Remote	3,786	16%	100%
Total	23,855		

	Mean	Std Dev.	Min	Max
Age	48.23	18.86	12	80+

Source: Australian Institute of Health and Welfare (2014).

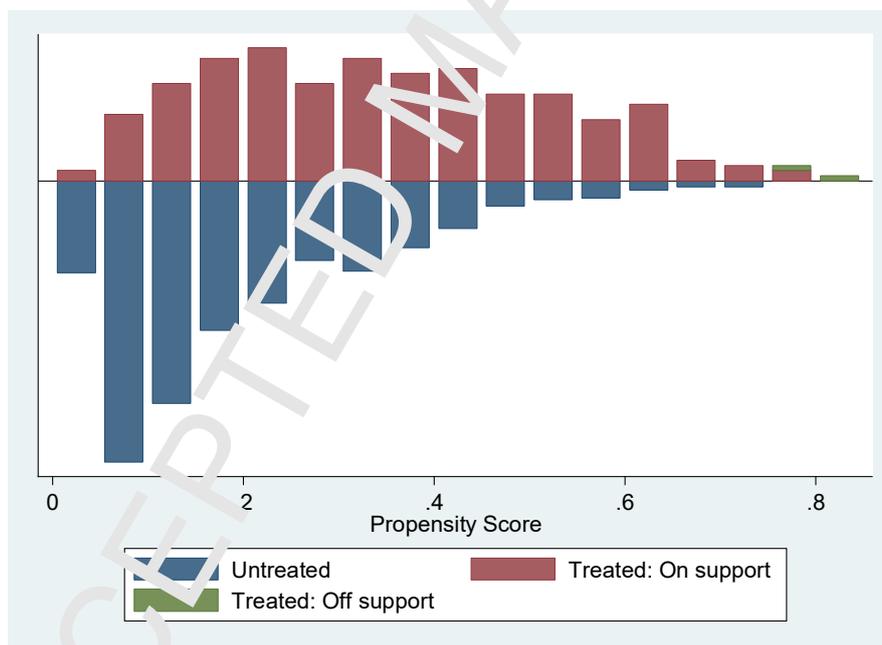
Table 8: Output table - caliper matching

Caliper	Treated coef.	Control coef. (ATT)	Difference (ATT)	T stat	Treated (n)	Control (n)
0.01	18.8708	16.8309	2.0399	3.20	236	778
0.02	18.8971	16.8769	2.0202	3.24	238	778
0.05	18.8436	16.8799	1.9637	3.19	240	778
0.10	18.8161	16.9628	1.8533	3.06	242	778
0.50	18.8161	16.2624	2.5537	4.47	242	778
Avg (tests satisfied)			1.96928			

Table 9: Matching test – caliper

Caliper	Mean bias	Median Bias	B	R
0.01	3.20%	3.00%	20.50	0.96
0.02	2.70%	2.40%	17.80	0.92
0.05	2.60%	2.20%	17.10	1.07
0.10	2.60%	2.00%	17.10	1.54
0.50	13.90%	11.40%	87.40	0.98

Figure 1: Propensity histogram - caliper



Note: The blue histogram gives the distribution of propensity scores for individuals who were not treated (non-recent methamphetamine users) while the red inverted histogram gives the distribution of scores for the treated (recent methamphetamine users). In all cases propensity scores are estimated with probit models. Those treated off-support (green) are dropped treatment observations whose propensity score is higher than the maximum propensity score of the controls. (Based on data from AIHW (2014)).

5.2 Nearest neighbour

Nearest neighbour matching also showed a significant difference between Kessler score of those treated and non-treated. The matching process was able to match 242 recent

methamphetamine users with 778 non-recent methamphetamine users that possessed similar characteristics. A matching test concluded that all neighbour restrictions greater than two satisfy the matching criteria (Mean Bias <5%, Median Bias <5%, Rubin's B $J < B < 25$, Rubin's $R < R < 2.0$).

Table 10: Output table - Nearest neighbour matching

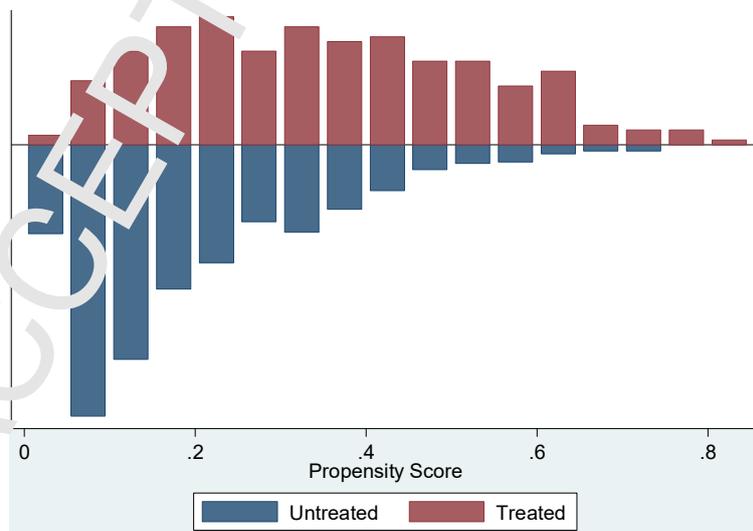
NN (X)	Treated coef.	Control coef. (ATT)	Difference (ATT)	T-stat	Treated (n)	Control (n)
1.00	18.81612	16.8037	2.0124	2.54	242	778
2.00	18.81612	16.6746	2.1415	3.09	242	778
3.00	18.81612	16.8292	1.9869	2.90	242	778
4.00	18.81612	16.8951	1.9210	2.84	242	778
Avg (tests satisfied)			1.9530%			

Table 11: Matching test – Nearest Neighbour

NN (X)	Mean bias	Median Bias	B	R
1.00	4.90%	4.00%	37.70	0.95
2.00	3.70%	3.10%	26.20	1.02
3.00	3.90%	3.30%	24.20	0.96
4.00	3.10%	3.10%	21.80	0.99

Figure 2 presents the matches for nearest neighbour (3). Matches were found at all propensity scores besides the upper quarter.

Figure 2: Propensity histogram - nearest neighbour



Note: The blue histogram gives the distribution of propensity scores for individuals who were not treated (non-recent methamphetamine users) while the red inverted histogram gives the distribution of scores for the treated (recent methamphetamine users). In all cases propensity scores are estimated with probit models. (Based on data from AIHW (2014)).

Taking the average of the ATT scores across each neighbour count that satisfies the matching criteria provides an estimated ATT of 1.954. An individual that has consumed methamphetamine within the last twelve months is likely to record a Kessler score 2.0 units higher than someone with similar demographic traits who did not. Results are consistent with caliper matching.

5.3 Kernel

Kernel matching provided statistically significant results indicating that there is a difference in Kessler score between those treated and those not treated: 242 recent methamphetamine users were matched to 778 non-recent methamphetamine users on the basis of background demographic traits. A matching test concluded that kernel matching satisfies the matching criteria (Mean Bias <5%, Median Bias <5%, Rubin's B $0 < B < 25$, Rubin's R $0 < R < 2.0$).

Figure 3 visualises the matches for Kernel matching. Matches were found at all propensity scores besides the upper quarter. The estimated ATT of methamphetamine on Kessler Score is 1.970. An individual that has consumed methamphetamine within the last twelve months is likely to record a Kessler score 2.0 units higher than someone with similar demographic traits who has not consumed methamphetamine not in the last 12 months. Results are consistent with both caliper and nearest neighbour matching.

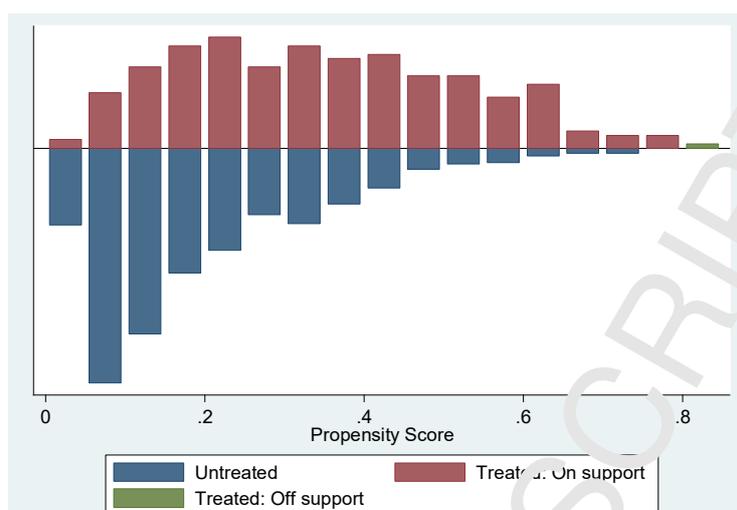
Table 12: Output table – Kernel matching

Treated coef.	Control coef. (ATT)	Difference (ATT)	T stat	Treated (n)	Control (n)
18.8423	16.8722	1.9701	3.19	242	778

Table 13: Matching test – Kernel

Mean bias	Median Bias	B	R
2.70%	2.70%	17.60	1.01

Figure 3: Propensity histogram – Kernel



Note: The blue histogram gives the distribution of propensity scores for individuals who were not treated (non-recent methamphetamine users) while the red inverted histogram gives the distribution of scores for the treated (recent methamphetamine users). In all cases propensity scores are estimated with probit models. Those treated off-support (green) are dropped treatment observations whose propensity score is higher than the maximum propensity score of the controls. (Based on data from AIHW (2014)).

5.4 Discussion

All matching techniques support the hypothesis that methamphetamine is detrimental to mental health. The findings from this model are consistent with previous studies conducted for the United States (Glaser-Edwards *et al.*, 2009; Looby and Earleywine, 2007) and South Africa (Plüddemann *et al.*, 2010). The average treatment effect on the treated is 2.0 Kessler units across all satisfied matching methods (rounded). The 2 unit increase in Kessler score moves recent users from the ‘low’ to the ‘moderate’ classification range for levels of psychological distress (Average Control Coefficient = 16.88, Average Treated Coefficient = 18.84).

Whilst the hypothesis is supported, the estimated magnitude of effect is small (5% of the difference between minimum and maximum Kessler scores). This is due to (i) the calculated difference between *recent* and *non-recent* methamphetamine users and (ii) the model controlling for confounding variables. Therefore, the magnitude of effect is expected to be smaller than what a basic comparison between users and non-users would suggest. Whilst an analysis of the difference in mental health scores between recent users and non-users is likely to show a larger average treatment effect of the treated, results are likely to not be robust due to (i) an imbalance in the characteristics of the matched treated and non-treated observations, and (ii) an over-reliance on the (limited) information provided in the NDSHS to control for background determinants of mental health scores. This hypothesis was tested and it was found

that (i) the average treatment effect of the treated increased (from 2 Kessler units under the current methodology to around 3 Kessler units depending on the match criteria applied), and (ii) the groups are unbalanced and tests do not satisfy Rubin's criteria for balance ($B < 25$; R between 0.5 and 2). Thus, it was inappropriate to match recent users with non-users.

Both recent and non-recent methamphetamine display levels of psychological distress higher than the population mean, suggesting that individuals consuming the drug most likely suffer from underlying psychological problems stemming from demographic or social factors. This implies that treatment methods need to concentrate on the psychological issues derived from the specific individual's life circumstances, not solely those presumed to be cultivated by methamphetamine abuse.

Failure of the matching processes to find appropriate matches from the non-treated group at high propensities ($\approx > 0.75$) suggests that there are certain background circumstances that exacerbate the use of methamphetamine. This finding is particularly interesting considering that those untreated have also used the drug but not within the last twelve months. Deeper analysis of these problematic background variables may point to why some individuals are capable of quitting methamphetamine whilst others are not.

For frontline health and enforcement workers these results propagate the need to be aware of the psychological issues present in those under the influence of the drug. Patients and suspects need to be approached in a manner that respects (i) the psychological distress caused by the effects of the drug, and (ii) the underlying psychological issues not attributable to the drug present in those using. The levels of psychological distress attributable to methamphetamine would be much greater when a user is under the immediate effects of the drug. Similarly, during withdrawals these levels of distress are more intense particularly with ice (Drug Info, 2016). This suggests that a need in this sector for more training programs such as the *Ice: Training for Frontline Workers* funded by the Victorian Government in 2016 to be implemented nationally (Victorian Government, 2016).

Our results can aid policy makers devising programs to reduce ice abuse related harm. Promoting the message that ice has detrimental effects on mental health may discourage use of the drug amongst those considering taking up the drug for the first time, particularly young people.

Given that the negative relationship between methamphetamine and mental health has been established, it is expected that the levels of psychological distress will only increase as the popularity and purity of ice, the purest form of methamphetamine, increases. It is expected

that the burden of methamphetamine abuse on mental health services will continue to grow unless policy makers can intervene with effective harm reduction strategies.

5.5 Limitations

There are some limitations of the analytical model applied here. The observed difference in Kessler score is likely to have underestimated the true prevalence of mental illness in methamphetamine users given that individuals with severe psychological distress symptoms warranting primary treatment or hospitalisation were excluded from the NDSHS. In addition, those homeless or incarcerated were also excluded from the survey. The reluctance of participants to answer questions with honesty due either to fear of retribution or breach of privacy could misrepresent the effect of methamphetamine on mental health. It is important that data collection agencies, particularly those dealing with drug users face to face, continue to collect useful data so that researchers can accurately keep track of harm associated with illicit substances.

A strong association between methamphetamine use and mental health issues has been revealed by propensity score matching. Propensity score matching is commonly deployed by experimental researchers when randomised control trials are not feasible. The method, like most statistical techniques, is not without limitations. It is prudent to discuss those limitations here.

Propensity score matching seeks to reduce the bias that arises when estimating treatment effects by accounting for confounding variables that predict receiving treatment. Our analysis is limited to data provided by the AIHW in the 2013 NDSHS. There could be omitted explanatory variables influencing a person's decision to consume methamphetamine that have not been revealed by the questionnaire. The inability to capture such variables could have introduced bias to our results. Further, an element of reverse causality (i.e., mental health decline causes methamphetamine consumption) could still be present in the relationship between mental health scores and recent methamphetamine use that has not been captured in this analysis.

King and Nielsen (2018) identify weaknesses in propensity score matching that may render the method less efficient than other matching methods. The authors assert that propensity score matching, through its objective to approximate a completely randomised experiment, can increase imbalance, inefficiency, model dependence and bias. It is through the process of randomly 'pruning' matches that propensity score matching can experience the

‘PSM paradox’, whereby after a given threshold any additional pruning *increases* imbalance in the characteristics of the matched treated and non-treated observations. The result is an increase in degree of model dependence in the statistical estimation of causal effects, researcher discretion (i.e., reporting treatment effects favourable to the researcher) and bias.

The results presented in this paper are evidently robust to not only changes in matching methodology (caliper, nearest neighbour and kernel), but a range of restriction criteria within those methodologies. Thus, a degree of confidence can be placed in the estimated effect of methamphetamine on mental health scores being due to group differences and not to the statistical technique.

Finally, the model did not control for the effects of other illicit substances that either the treated or non-treated groups could have consumed. Nevertheless, matching recent methamphetamine users with non-recent methamphetamine users on the basis of similar explanatory variables allows for the satisfactory assumption that individuals from both groups had a similar likelihood of having consumed other illicit substances.

6. Estimated financial costs to the mental health sector

Statistics available from the NDSHS and Medibank, combined with the results of the model can be used to approximate the mental health costs associated with methamphetamine abuse. Such an estimate would allow for a cost-benefit analysis of government spending in this area.

Results from PSM show the average treatment effect on the treated across all satisfied matching techniques to be 1.95 Kessler units. As 425 out of 23,855 NDSHS respondents (1.78%) indicated that they had consumed methamphetamine in the previous twelve months,⁶ the portion of Kessler unit attributable to methamphetamine abuse amongst the population is:

$$1.95 \times 0.0178 = 0.035 \text{ Kessler units per person.}$$

Since a perfectly healthy Kessler score is 10.0, and the average Kessler score of Australians based on the NDSHS (2013) is 15.46, the average deficit per person is 5.46. The portion of the average deficit per person attributable to methamphetamine abuse is therefore:

$$\frac{0.035}{5.46} * 100 = 0.64\%$$

⁶ No respondents aged 80 or above indicated that they had consumed methamphetamine in the previous 12 months, therefore this figure is not affected by the omission of these individuals.

Medibank (2013) reports that Australians spent \$28.55 billion on supporting people with mental illness in 2013.⁷ On the assumption that mental health expenditure is in proportion to individuals with Kessler score deficits,⁸ the amount of mental health expenditure attributable to methamphetamine abuse is calculated as follows:

$$\frac{0.035}{5.46} \times \$28.55bn = \$183,012,821$$

Adjusting for inflation,⁹ the estimated cost is \$196,584,062 in 2017 dollars.

It is conservatively estimated that the ice epidemic costs Australians \$197 million a year in payments to mental health services alone. This figure does not consider other costs related to ice abuse such as physical health, crime, domestic violence or uncaptured qualitative social costs such as pain, suffering and family breakdown. The cost to Australian tax payers is expected to increase if the ice epidemic continues to spread and more people become addicted to the drug. Strategies to combat the epidemic such as the *National Ice Action Strategy* implemented by the federal government in 2015 (Department of Prime Minister and Cabinet, 2015b) are crucial. Policy makers need to react quickly with programs that can effectively prevent consumption amongst Australians. Funds allocated towards harm reduction could be saved through reduced costs to the mental health sector.

7. Conclusion

Crystal methamphetamine poses significant risks to users, their families and broader society. Highly addictive and linked to unpredictable bursts of violent anger, the drug is comparatively more worrisome than previous illicit drug abuse problems Australia has faced. Statistics from various sources including household surveys, detainee surveys and police reports maintain that methamphetamine users are substituting into ice at an increasing rate. The literature at present has not caught up with consumer preferences in the illicit drug market. This paper expands on research in this area and provides information for policy makers developing harm reduction strategies.

The aim of this research is to discover the effect that methamphetamine has on mental health. By providing estimates on the amount by which a user's mental health is affected by the drug, it is hoped that at-risk individuals may be less inclined to experiment with the drug. In addition, results from a quantitative analysis could justify additional allocation of funds

⁷ After excluding Department of Defence related expenditure (\$366m).

⁸ Cost per Kessler unit is assumed to be linear.

⁹ Total change in cost is 7.4%, over 4 years, at an average annual inflation rate of 1.8%. (Reserve Bank of Australia, 2018)

towards training programs aimed at educating and protecting the safety of frontline workers. An understanding of the genuine effect of methamphetamine on mental health could shape future rehabilitation programs such as personalised psychological care.

Propensity score matching was applied to estimate the difference in mental health scores between recent and non-recent methamphetamine users while controlling for background explanatory variables. Methamphetamine consumption in the previous twelve months is found to increase psychological distress by 2.0 Kessler units, an increase sufficient enough to move recent users from the 'low' to the 'moderate' classification for levels of psychological distress. Results remained statistically significant over caliper, radius and kernel matching techniques and each method satisfied diagnostic checks.

An estimate of national mental health expenditure associated with methamphetamine abuse provided a figure of \$197 million annually in 2017 dollars. This estimate was based on Medibank (2013) and assumed expenditure to be proportional to deficits in Kessler score.

Data from the NDSHS excluded individuals that were receiving residential care for mental health related problems. Therefore, the results potentially understate the magnitude of effect of methamphetamine on mental health. Future research should develop models based on data samples that include methamphetamine users currently incarcerated or receiving residential care.

Results from the model showed that both non-recent and recent methamphetamine users exhibit levels of psychological distress above the population mean. An in-depth assessment of these underlying psychological issues could assist in the development of effective treatment methods and psychiatric care.

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