What are the associations between methamphetamine use and criminal offending, and are these associations likely to be causal?

Christchurch Health and Development Study (University of Otago Christchurch) – Methamphetamine in New Zealand Research Programme

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The purpose of this report is to examine the associations between a series of offending outcomes over the period from age 17 to age 40 and the casual and regular use of methamphetamine, using data from the Christchurch Health and Development Study database. The reported analyses (below) show the estimates of association between five different classifications of offending and methamphetamine use, both before and after adjustment for confounding and contemporaneous covariate factors.

Summary

This report describes a series of analyses using data from the Christchurch Health and Development Study, a cohort of approximately 1000 people born in Christchurch in mid-1977 and followed to age 40 in 2017. The analyses examine the relationship between casual and regular methamphetamine use, and a series of criminal offending outcomes over the period from age 17 years to age 40 years. A key feature of the analyses is the use of both confounding (time-invariant) and contemporaneous (time-dynamic) covariate factors in the model to test the possible causal role of methamphetamine use in criminal offending.

The distribution of criminal offending data according to casual and regular (at least weekly) methamphetamine use shows that methamphetamine users had rates of self-reported criminal offending that were considerably higher than those who did not use methamphetamine, a pattern that was shown for all five offending outcomes (theft; assault; use of a weapon; property crime; fraud). The analyses showed that, even after controlling for both time-invariant and time-dynamic covariate factors, there remained an association between casual methamphetamine use for theft, with the risk of theft being 2.10 times higher than that of non-users. For regular users, theft, assault, use of a weapon, and fraud maintained an association with methamphetamine use after adjustment, with adjusted risks ranging from 2.82 to 9.03. The results of these analyses suggest that methamphetamine use, and in particular regular use is likely to play a causal role in criminal offending, although we are unable to ascertain the extent to which these self-reported criminal offences are related to participation in the illicit drug trade, or to the specific effects of methamphetamine itself, as these were not able to be measured in the context of the present study.

Contents

1. Main aim and causality test

In the present investigation, we aimed to examine the potentially causal role played by methamphetamine use in increasing the risk of criminal offending. In order to ascertain causality in a study using observational data, it is necessary to follow the criteria set out by Bradford Hill in 1965 [1]. Specifically, using the data available, there are three criteria that allow us to determine whether causality should be inferred. The first of these is dose/response, in which methamphetamine use, or higher levels of methamphetamine use, is associated with higher rates of reporting criminal offending. The second of these criteria is robustness to control for confounding factors. These factors are variables measured prior to methamphetamine use which are linked to an increase in the likelihood of using methamphetamine (e.g. novelty-seeking at age 16). Robustness in this case means that the association between methamphetamine use and criminal offending remains statistically significant after control for these factors. The third of the criteria employed in these analyses is specificity, in which, after controlling for factors occurring contemporaneously with both methamphetamine use and criminal offending (e.g. alcohol use disorder between 16 and 40 years of age), the association between methamphetamine use and criminal offending remains statistically significant.

2. Measures

2.1. Methamphetamine use (ages 16--40 years)

At each assessment from age 18 to age 40, cohort members were queried about their use of a range of illicit drugs. One aspect of this questioning concerned methamphetamine. The question stem was worded "Since you turned (age) have you used the following, and how often?". The second part of the question listed a series of substances, with methamphetamine use described as "Methamphetamine, speed, P, ice, etc."[1] Participants were asked about their substance use from the prior to the current study wave.

In the main analyses presented in this report, a methamphetamine use variable with three levels was considered. This variable was sectioned to include a group with participants who had reported not using methamphetamine in any of the study waves (reference group), a group with participants who had reported casual use of methamphetamine (less than weekly) in at least one of the study waves, and a group with participants who had reported using methamphetamine regularly (at least weekly) in at least one of the study waves. Likewise, preliminary analyses including methamphetamine use contrasted values for the *casual methamphetamine use group* and the *regular methamphetamine use group* with values for the *no methamphetamine use group*.

2.2. Criminal offending outcome measures (ages 17-40 years)

We used a series of variables representing different classes of self-reported criminal offending, modelling the association between each of these and methamphetamine use from ages 17 to 40. The classification of criminal offending is as follows.

At ages 18, 21, 25, 30, 35, and 40, respondents were questioned about their criminal behaviours in the twelve-month period prior to the current assessment using the Self-Report Delinquency Inventory (SRDI) [2] and additional custom-written survey items. For the purposes

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[1] The reference to "P" and "ice" first appeared in the age 30 (2007) assessment due to their common use as slang terms from that time.

of the present investigation, a number of classifications of types of offending were created using a subset of these questions. This information was used to derive a categorical (yes/no) measure of the number of self-reported offenses, across several categories. These classifications were used in a previous analysis of the association between alcohol problems and criminal offending in the CHDS cohort [3]. The classifications of offences and the items used to create these classifications are described below. The classifications included:

Theft/burglary/vehicle conversion. This category was assessed by several items concerning: petty theft; grand theft (cash or goods over $500); theft from an automobile; breaking and entering; handling stolen goods; shoplifting; burglary; and taking and driving away an automobile without permission.

Assault. Assault was assessed via responses to three items concerning physical assault and fighting, including: assaulting a person with whom the respondent lived; assaulting a person with the idea of hurting them; and being involved in a gang (group) fight.

Use of a weapon. Use of a weapon was assessed using four items concerning: use of a weapon in a violent assault; using a weapon against someone with whom the respondent lived; aggravated robbery (using a weapon to rob a person or business); and carrying a hidden weapon.

Property damage/vandalism/arson. These forms of offending were assessed via two items concerning: destroying or damaging property that did not belong to the respondent (vandalism); and setting fire to a house, building, car, or other property.

Fraud/embezzlement/misappropriation of funds. Fraud and related offences were assessed by several items pertaining to: obtaining goods via deception; stealing money from employers or others whom had entrusted the respondent with money; failure to pay bills; and benefit fraud.

2.3. Potential confounding factors: Childhood/ adolescent predictors of methamphetamine use and criminal offending in adulthood (ages 0-16 years)

We examined the database of the study to determine the variables that would be the most important and useful in examining childhood/ adolescent factors that may confound the association between methamphetamine use and crime. This was based in previous literature and research within the Christchurch Health and Development Study [4-7]. Variables in five domains were considered as follows.

2.3.1. Measures of family socio-economic and demographic background

Maternal age. Assessed at the time of the survey child's birth.

Family living standards (0-10 years). At each year, a global assessment of the material living standards of the family was obtained by means of an interviewer rating. These were averaged over the period 0-10 years.

Maternal and paternal education (at birth). Parental education level was assessed at the time of the survey child's birth reflecting the highest level of educational achievement attained, using a three-level scale. These levels were: no secondary school qualifications; at least one secondary school qualification; tertiary qualification.

Family socio-economic status (SES, at birth). Family SES was assessed at the time of the survey child's birth using the Elley-Irving [8] scale of socio-economic status for New Zealand.

<u>Single parenthood.</u> Family structure was assessed at the time of the survey child's birth.

<u>Averaged family income (0–10 years).</u> At each year, estimates of the family's gross annual income were obtained from parental report and were recoded into decile [2] categories.

2.3.2. Measures of family functioning

<u>Parental illicit drug use (11 years).</u> At age 11, parents were questioned regarding their history of illicit drug use. The cohort member was classified as having a parent history of illicit drug use if one of his/her parents was reported to have a history of illicit drug use.

<u>Parental alcohol problems (15 years).</u> This was assessed at age 15 years via parental report. These reports were used to form a dichotomous measure of whether or not the young person's parents reported experiencing problems with alcohol.

<u>Parental criminality (15 years).</u> At age 15 years, parents were questioned as to whether any parent had a history of criminal offending. The cohort member was classified as having a parent history of criminality if one of his/her parents was reported to have a history of offending.

<u>Changes of parents (0–15 years).</u> At each assessment from birth to 15 years, information was gathered on changes in the cohort member's family situation since the previous assessment. Using this information, an overall measure of family instability was constructed up to age 15, representing the number of changes in parental figures (due to separation, divorce, death, or re-partnering) in the home during the life of the cohort member to age 15.

<u>Parental Bonding (Maternal and Paternal Care and Protection; 16 years).</u> To measure parental bonding, the maternal care and protection scales of the Parental Bonding Instrument (PBI) [9] were administered to the cohort members at the age of 16 years. The young person was asked to rate their mother on the PBI items describing the quality of maternal care and protection throughout their childhood. The care scale measures the extent to which the parents provide support, affection and nurturing with a high score indicating high levels of care. The protection scale measures the extent to which parents exhibit tendencies to over protection or over control with a high score indicating tendencies to over control. The reliabilities of the resulting scale scores were assessed using coefficient alpha and found to be good: maternal care α = .89; paternal care α = .91; maternal over protection α = .85; paternal over protection α = .87.

2.3.3. Individual, personality and behavioural factors

<u>Gender.</u> Recorded at birth.

<u>Child conduct and attention problems, and anxious/withdrawn behaviour (7–9 years).</u> When sample members were aged 7–9 years, information on child behaviour problems was obtained from parental and teacher report using a behaviour questionnaire combining items from the Rutter et al. [10] and Conners [11] parental questionnaires. (α = .97; .93; and .92, respectively).

<u>Neuroticism (14 years).</u> This was assessed using a short form version of the Neuroticism scale of the Eysenck Personality Inventory [12] at age 14. (α = .80).

<u>Novelty-seeking (16 years).</u> Novelty-seeking was assessed at age 16 using the novelty seeking items from the Tridimensional Personality Questionnaire [13] (α =.76).

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[2] Decile categories are obtained by ranking income estimates from highest to lowest, and dividing these into groups representing 10% of the overall distribution. Because income is a highly skewed measure, the decile score serves as the income measure.

Childhood IQ (8-9 years). At ages 8 and 9 years, cohort members were assessed using the revised version of the Wechsler Intelligence Scale for Children (WISC-R [14]) modified for New Zealand conditions. At each age, total IQ scores were computed using the method described in the test manual. The reliabilities of these measures assessed by using split half methods ranged from .93 to .95. The IQ measure used in the present analyses was based on an average of the total IQ score at the two ages.

GPA (11-13 years). School performance was assessed via teachers' ratings in each of five areas of the curriculum (reading, handwriting, written expression, spelling, mathematics) using a 5-point scale ranging from very good to very poor. To provide a global measure of the child's educational achievement over the interval from 11-13 years, the teacher ratings were summed across years and curriculum areas and then averaged to provide a teacher rating grade point average for each child.

2.3.4. Abuse exposure

Childhood sexual abuse (0-16 years). At ages 18 and 21 years, sample members were questioned about their experience of sexual abuse during childhood (<16 years) [5]. Questioning spanned an array of abusive experiences from episodes involving non-contact abuse (e.g. indecent exposure) to episodes involving attempted or completed intercourse. A four-level scale was devised reflecting the most extreme form of sexual abuse reported by the young person at either age. The levels were: no sexual abuse; non-contact sexual abuse; sexual abuse involving physical contact but not penetration; penetrative sexual abuse.

Childhood physical abuse (0-16 years). At ages 18 and 21 years, sample members were questioned about their experience of physical punishment during childhood (<16 years) [15]. Questioning spanned an array of experiences with physical punishment and the frequency with which these occurred during childhood. A four-level scale was devised reflecting the most extreme form of physical punishment reported by the young person at either age. These levels were: no physical punishment; occasional physical punishment; regular physical punishment; harsh and abusive physical punishment.

Exposure to parental intimate partner violence (0-16 years). At the age of 18, sample members were questioned concerning their experience of violence between parental figures during their childhood (prior to age 16 years), with questions derived from the Conflict Tactics Scale [CTS: 16]. The items were chosen on the basis that the behaviours could have been readily observed and reported on by the participant, and also to span the potential range of violent behaviour from verbal abuse to physical assault. Separate questioning was conducted for violence initiated by the father against the mother and for violence initiated by the mother against the father, and combined into a single scale score representing overall exposure across both parents.

2.3.5. Adolescent problem behaviour

Information concerning disruptive childhood behaviour was obtained at two assessments taking place when the sample members were aged 15 and 16 years. At each age, sample members were interviewed on a comprehensive mental health interview that examined aspects of mental health and adjustment over the previous 12 months. A parallel interview was also conducted with the child's mother at each assessment stage.

Conduct disorder, oppositional defiant disorder, attention deficit hyperactivity disorder (14-16 years). As part of the assessments at each age, information was obtained on DSM-III-R [17]

symptom criteria for disruptive childhood behaviours, including conduct disorder (CD), oppositional defiant disorder (ODD), and attention deficit hyperactivity disorder (ADHD) [18]. For child self-report, the assessment of ODD and ADHD was based on the relevant sections of the Diagnostic Interview Schedule for Children (DISC) [19], whereas CD was assessed using the Self-Report Early Delinquency (SRED) scale [20]. For parental reports, ODD and ADHD were assessed using items from the Revised Behaviour Problems Checklist (RBPC) [21], and CD was assessed using a parent version of the SRED. The combined symptom data thus comprised information on DSM-III-R symptom criteria for two separate 12-month periods (ages 14-15 and 15-16 years) from two sources (parent, self-report).

Alcohol use disorders (15-16 years). At each interview at ages 15 and 16, cohort members were asked a series of questions concerning whether the individual experienced any problems relating to their drinking. This measure was based on the Diagnostic Interview Schedule for Children (DISC) [22], in order to obtain information pertaining to DSM-III-R [17] symptoms of alcohol abuse/alcohol dependence (alcohol use disorder). These data allowed classification of participants as to whether they meet DSM criteria for an alcohol use disorder; during the period following the previous assessment.

Internalizing disorders (14-16 years). Parallel to the assessment of disruptive behaviour disorders, ages 15 and 16 years cohort members and their parents were questioned about symptoms of major depression and anxiety disorders (generalized anxiety disorder; over-anxious disorder; social phobia; simple phobia) occurring in the previous 12 months using the relevant sections of the Diagnostic Interview Schedule for Children [DISC: 19]. These items were used to classify participants according to DSM-III-R [17] symptom criteria for major depression and anxiety disorders. Participants were classified as having major depression or an anxiety disorder during the period 14-16 years if they met criteria for disorder on the basis of either self or parental report over the period 14-16 years.

Deviant peer affiliation (age 15). At the assessment at age 15, cohort members and their parents were asked to indicate how many of the child's friends were "deviant", defined as smoking cigarettes, drinking alcohol, using illicit drugs, or who committed crimes. The larger of the two answers (child; parent) was used as the measure.

2.4. Potential mediating factors: Contemporaneous variables to methamphetamine use and criminal offending in adulthood (ages 16-40 years)

Several potential covariates[3], measured contemporaneously with methamphetamine use, will also be employed as factors that potentially mediate the associations between methamphetamine use and criminal offending. Previous CHDS analyses have shown that substance use in adulthood tends to "cluster" particularly in early adulthood, and specifically for illicit drugs in early and later adulthood [23, 24]. In addition, mental health disorders such as depression and anxiety [25, 26], as well as life stress [27] and unemployment [28, 29] have also been shown to be associated with substance use outcomes in analyses of CHDS data. Finally, it is clear that factors such as substance use, life stress and unemployment are associated with adult criminality [30]. The variables considered include:

Alcohol use disorders (16-40 years). At each interview from age 18 years, cohort members were asked a series of questions concerning whether the individual experienced any problems relating to their drinking. This measure was based on the Composite International Diagnostic

[3] In this context, "covariate" refers to time-dynamic covariate factors that may influence the likelihood that an individual commits a criminal offence during a particular time period.

Interview (CIDI) [31] at ages 18 , 21, 25, 30, 35 and 40 years, in order to obtain information pertaining to DSM-IV (age 18 and above) [32] symptoms of alcohol abuse/alcohol dependence (alcohol use disorder). These data allow classification of participants as to whether they meet DSM criteria for an alcohol use disorder during the period following the previous assessment.

Major depression (15-40 years). Cohort members completed the CIDI at ages 18, 21, 25, 30, 35, and 40 years. These data were used to classify individuals as to whether they met DSM-IV criteria for major depression over the intervals 15-18 years, 18-21 years, 21-25 years, 25-30 years, 30-35 years, and 35-40 years.

Other substance use disorders (15-40 years). At ages 18, 21, 25, 30, 35 and 40 years, cohort members were questioned about their substance use behaviours and problems associated with substance use since the previous assessment (tobacco, cannabis), based on the CIDI (items for cigarette smoking were custom written). Using this information cohort members were classified as meeting DSM-IV criteria for nicotine dependence and cannabis dependence over the intervals 15-18 years, 18-21 years, 21-25 years, 25-30 years, 30-35 years, and 35-40 years (for nicotine dependence, the measure refers to current ND at ages 18, 21, 25, 30, 35 and 40 years).

Unemployment (18-40 years). At each assessment, starting at age 21, cohort members were asked whether they had been unemployed and looking for work for three or more months during any calendar year since the previous assessment (ages 18–21, 21–25, 25–30, 30–35, and 35-40 years).

Stressful life events other than unemployment (18-40 years). Life events were assessed for each 12-month period during ages 18–40 years using a 30-item inventory based on the Social Readjustment Rating Scale [33] supplemented by custom-written survey items. These items spanned several domains, including, for example, death and illness, relationship problems and difficulties, and crime victimization. All items were scored on a 0 to 4 scale (0 = *no event*, 1 = *not upset or distressed*, 2 = *a little upset or distressed*, 3 = *moderately upset or distressed*, and 4 = *very distressed*). Using this information, a measure of exposure to stressful life events was created by summing the scores for each item for each 12-month period, and then summing over each assessment period, resulting in a total life events distress score for the periods 18–21, 21–25, 25–30, 30–35, and 35-40 years.

3. Preliminary findings

3.1. Association between criminal offending outcome measures and lifetime methamphetamine use

Based on the criteria set out by Bradford Hill in 1965 to assess causality in an observational study [1], it is important to assess whether methamphetamine use, or higher levels of methamphetamine use, is associated with higher rates of reporting criminal offending (dose-response criterion).

Table 1 shows the cohort classified according to their self-reported methamphetamine use (casual use, regular use) and the number of cohort members in each category at each assessment. Table 1 shows the percentage of those cohort members who self-reported at least one offence for each category of offending, at each assessment at ages 18, 21, 25, 30, 35 and 40. Table 1 also shows that for all classes of offending and for most assessments, those reporting having used methamphetamine casually reported higher levels of offending than those who did not report using methamphetamine. This pattern was similar for those who

reported using methamphetamine regularly, with the percentage of those offending in this group being most times substantially larger than of those who reported using the drug casually. It is also clear that rates of offending generally declined as the cohort aged.

Table 1: Criminal offending rates classified by methamphetamine use and study wave

	No methamphetamine use	Casual methamphetamine use	Regular methamphetamine use
Age 18	**(n = 991)**	**(n = 26)**	**(n = 8)**
Theft	12.1	65.4	87.5
Assault	15.5	50.0	87.5
Use of a weapon	4.6	19.2	62.5
Property crime	6.4	26.9	62.5
Fraud	4.6	30.8	75.0
Age 21	**(n = 955)**	**(n = 50)**	**(n = 6)**
Theft	5.6	32.0	66.7
Assault	5.7	24.0	83.3
Use of a weapon	2.1	10.0	66.7
Property crime	3.4	16.0	16.7
Fraud	4.7	30.0	66.7
Age 25	**(n = 778)**	**(n = 198)**	**(n = 27)**
Theft	2.2	7.1	11.1
Assault	4.5	6.1	14.8
Use of a weapon	0.6	1.5	14.8
Property crime	1.9	3.0	7.4
Fraud	3.0	6.1	18.5
Age 30	**(n = 845)**	**(n = 121)**	**(n = 21)**
Theft	1.5	3.3	23.8
Assault	3.4	7.4	19.1
Use of a weapon	0.8	0.8	14.3
Property crime	0.4	1.7	4.8
Fraud	0.2	2.5	14.3

Age 35	(n = 887)	(n = 64)	(n = 11)
Theft	6.0	17.2	18.2
Assault	1.9	4.7	0.0
Use of a weapon	0.9	0.0	0.0
Property crime	0.5	4.7	9.1
Fraud	0.8	1.6	9.1
Age 40	(n = 833)	(n = 58)	(n = 9)
Theft	0.6	8.6	44.4
Assault	1.1	5.2	33.3
Use of a weapon	0.1	0.0	11.1
Property crime	0.6	1.7	11.1
Fraud	3.5	12.1	22.2

3.2. Association between childhood/ adolescent predictors of methamphetamine use in adulthood and lifetime methamphetamine use

Based on the criteria set out by Bradford Hill in 1965 to assess causality in an observational study [1], it is important to assess whether the association between methamphetamine use and criminal offending remains statistically significant after controlling for factors which were measured prior to methamphetamine use and are linked to an increase in the likelihood of using methamphetamine (robustness criterion).

Below are illustrated the associations between each of the childhood/adolescent predictors (confounding factors) detailed previously, and lifetime methamphetamine use (ages 16-40). Spearman's r was used as the measure of association as lifetime methamphetamine use was a dichotomous variable, and many of the measures reported are also categorical in nature (Spearman's r is a non-parametric statistic, which therefore does not require an underlying assumption of a normal distribution of the two variables for which a correlation is being estimated). An important assumption for the evaluation of confounding factors in observational data is that the fixed (time-invariant) confounding factors must be associated with the exposure (in this case, methamphetamine casual use/regular use).

For social research data such as that reported below, a correlation with an absolute value of 0 to 0.9 is considered "weak" in magnitude, 0.10 to 0.19 is considered "moderate", and 0.20 or higher is considered "strong". P-values refer to "probability values", which refer to the likelihood of error in conclusions drawn using the analysed data. Our maximum acceptable likelihood of error is set at 5% as a matter of convention. P-values larger than this are referred to as "non-significant", while p-values smaller than this are referred to as "significant" (and are shown in bold, with significance level noted at the foot of Table 2).

Table 2: Associations between potential confounding factors and lifetime methamphetamine use

Measure	Casual methamphetamine use	Regular methamphetamine use
Measures of family socio-economic and demographic background		
Maternal age (at birth)	-.03	**-.07***
Family living standards (0-10 years)	-.06	-.05
Maternal education (at birth)	.00	.05
Paternal education (at birth)	-.06	-.00
Family socio-economic status (at birth)	-.00	**-.09****
Single parenthood (at birth)	.02	.03
Averaged family income (0-10 years)	-.04	-.02
Measures of family functioning		
Parental illicit drug use (11 years)	.06	**.12*****
Parental alcohol problems (15 years)	.02	.06
Parental criminality (15 years)	.05	**.10*****
Changes of parents (15 years)	**.07***	**.12*****
Maternal care (16 years)	-.04	-.03
Paternal care (16 years)	**-.09***	**-.08***
Maternal over-protection (16 years)	**.07***	.02
Paternal over-protection (16 years)	**.10****	.05
Individual, personality and behavioural factors		
Gender (at birth)	**-.14*****	-.06
Child conduct problems (7-9 years)	**.09****	**.13*****
Child attention problems (7-9 years)	**.07***	**.11****
Anxious/withdrawn behaviour (7-9 years)	**-.09****	**.10****
Neuroticism (14 years)	-.06	**-.07***
Novelty-seeking (16 years)	**.22*****	**.16*****
Childhood IQ (8-9 years)	.06	-.01

GPA (11-13 years)	-.00	.03
Abuse exposure		
Exposure to childhood sexual abuse (0-16 years)	-.02	.04
Exposure to childhood physical punishment (0-16 years)	.04	**.09****
Exposure to parental IPV (0-16 years)	.03	.04
Adolescent problem behaviour and mental health		
Conduct disorder (14-16 years)	**.19***	**.16***
Oppositional defiant disorder (14-16 years)	**.17***	**.12***
Attention deficit hyperactivity disorder (14-16 years)	**.11***	**.07***
Alcohol use disorder (15-16 years)	**.10****	**.14***
Major depression (14-16 years)	-.06	-.01
Anxiety disorder (14-16 years)	-.05	.02
Deviant peer affiliation (15 years)	**.16***	**.15***

* p < .05; ** p < .01; *** p < .001

As can be seen from Table 2, childhood, family functioning and abuse exposure variables were for the most part weakly associated with later methamphetamine use. On the other hand, behaviour problems (externalizing) in childhood and adolescence (and association with deviant peers) were moderately associated with later methamphetamine use. In terms of personality, novelty seeking was strongly associated with methamphetamine use (and moderately with regular use). The focus of the causal models detailed below will be the statistically significant (p < .05) variables noted above.

It is also worth noting that the profile of potential confounding variables differs with respect to whether a person used methamphetamine casually, or used methamphetamine regularly (at least weekly) at some point. Predictors varied both in their strength of association with the methamphetamine variables, and whether they reached statistical significance. This suggests that models of both "casual use" and "regular use" should employ a common set of potential confounding factors.

3.3. Association between contemporaneous variables, lifetime methamphetamine use and criminal offending

Based on the criteria set out by Bradford Hill in 1965 to assess causality in an observational study [1], it is important to assess whether the association between methamphetamine use and criminal offending remains statistically significant after controlling for factors occurring contemporaneously with both methamphetamine use and criminal offending (specificity criterion).

The associations between contemporaneous predictors, criminal offending, and methamphetamine use are shown in Table 3 below. The associations between these factors

are displayed as it is necessary that contemporaneous variables be associated with both the exposure (methamphetamine use) and outcome (criminal offending) measures for these to inform inferences concerning causality (methamphetamine use causing criminal offending). As per previous section, Spearman's *r* and p-values are used to assess the relationship between factors.

Table 3: Associations between contemporaneous predictors, lifetime methamphetamine use and criminal offending

Measure	Casual use	Regular use	Theft	Assault	Use of weapon	Property	Fraud
Alcohol use disorder (16-40 years)	.18***	.09**	.21***	.24***	.16***	.22***	.19***
Major depression (15-40 years)	.07*	.07*	.05	.06*	.05	.05	.08*
Nicotine dependence (15-40 years)	.24***	.13***	.12***	.15***	.11*	.09*	.16***
Cannabis use disorder (15-40 years)	.26***	.15***	.24***	.20***	.19***	.25***	.30***
Unemployment (18-40 years)	.18***	.08*	.02	-.01	.02	.02	.12***
Life stress (18-40 years)	.22***	.10**	.07*	.07*	.06*	.04	.12***

* p < .05; ** p < .01; *** p < .001

As can be seen in the table, the contemporaneous measures are associated with casual methamphetamine use, and also with regular use, although the magnitude of the association was generally smaller for regular use. In addition, each of the measures was significantly associated with one or more types of criminal offending. Thus, all contemporaneous measures will be considered in the causal models detailed below.

4. Main findings

To model the repeated measures data in order to estimate the associations between casual methamphetamine use/regular methamphetamine use and criminal offending, logistic generalized estimating equation (GEE) models were fitted [34]. These models estimated the log odds of each of the five criminal offending outcome measures as a linear function of casual methamphetamine use/regular methamphetamine use and age. Random effects models provide a single estimate of the regression coefficients pooled over the repeated measures of the outcome variable.

In the next step of the modelling, the base models were extended, in order to fit two multivariate logistic GEE models of the associations between casual methamphetamine use/regular use and criminal offending outcomes, adjusted for the potentially confounding and

contemporaneous factors listed in Tables 2 and 3. These models were fitted in steps, as follows.

- In the second model, the fixed predictors presented in Table 2 (i.e. measures of family socio-economic and demographic background; measures of family functioning; individual, personality and behavioural factors; abuse exposure; and adolescent problem behaviour) were entered in blocks, with forward and backward elimination of variables to identify a stable and parsimonious set of confounding factors.

- The third model extended the second model by including the time-dynamic factors listed in Table 3 (i.e. alcohol use disorder; major depression; nicotine dependence; cannabis use disorder; unemployment; and life stress), with the factors being entered into the models simultaneously.

All models were fitted using Stata 16 [35].

4.1. Wave-related predictors of criminal offending

Table 4 shows the parameter estimates, standard errors of estimate and probability values for the base models of criminal offending. Table 4 shows that, relative to the period 17-18 years (the reference wave), rates of criminal offending tended to be significantly ($p < .05$) lower at each subsequent assessment wave, with the exception of fraud, which did not differ significantly from baseline (wave 1) in ages 20-21 and 39-40 years for both casual and regular use and at ages 24-25 only for casual use; and property crime, which did not differ significantly from baseline in ages 20-21 years only for regular use.

Table 4: Parameter estimates for wave-related predictors of criminal offending, ages 17-40

Outcome	Assessment wave	Casual methamphetamine use			Regular methamphetamine use		
Theft		**B**	**S.E.**	**p**	**B**	**S.E.**	**p**
	17-18 (wave 1)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)
	20-21 (wave 2)	**-.83**	**.15**	**<.0001**	**-1.52**	**.48**	**<.01**
	24-25 (wave 3)	**-1.74**	**.25**	**<.0001**	**-3.22**	**.48**	**<.0001**
	29-30 (wave 4)	**-2.19**	**.30**	**<.0001**	**-4.01**	**.65**	**<.0001**
	34-35 (wave 5)	**-.80**	**.17**	**<.0001**	**-2.24**	**.53**	**<.0001**
	39-40 (wave 6)	**-3.16**	**.47**	**<.0001**	**-3.47**	**.63**	**<.0001**
Assault		**B**	**S.E.**	**p**	**B**	**S.E.**	**p**
	17-18 (wave 1)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)
	20-21 (wave 2)	**-1.10**	**.15**	**<.0001**	**-1.11**	**.51**	**<.05**
	24-25 (wave 3)	**-1.29**	**.18**	**<.0001**	**-3.07**	**.53**	**<.0001**
	29-30 (wave 4)	**-1.65**	**.20**	**<.0001**	**-2.53**	**.52**	**<.0001**

		B	S.E.	p	B	S.E.	p
	34-35 (wave 5)	**-2.22**	**.26**	**<.0001**	**-4.02**	**1.07**	**<.0001**
	39-40 (wave 6)	**-2.81**	**.34**	**<.0001**	**-2.81**	**.69**	**<.0001**
Use of a weapon		**B**	**S.E.**	**p**	**B**	**S.E.**	**p**
	17-18 (wave 1)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)
	20-21 (wave 2)	**-.75**	**.23**	**<.01**	**-.65**	**.23**	**<.01**
	24-25 (wave 3)	**-2.12**	**.34**	**<.0001**	**-1.90**	**.33**	**<.0001**
	29-30 (wave 4)	**-1.93**	**.34**	**<.0001**	**-1.84**	**.35**	**<.0001**
	34-35 (wave 5)	**-1.97**	**.37**	**<.0001**	**-1.94**	**.37**	**<.0001**
	39-40 (wave 6)	**-3.25**	**.68**	**<.0001**	**-3.22**	**.68**	**<.0001**
Property crime		**B**	**S.E.**	**p**	**B**	**S.E.**	**p**
	17-18 (wave 1)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)
	20-21 (wave 2)	**-.66**	**.20**	**<.01**	-.80	.60	.18
	24-25 (wave 3)	**-1.18**	**.27**	**<.0001**	**-2.54**	**.61**	**<.0001**
	29-30 (wave 4)	**-2.99**	**.60**	**<.0001**	**-2.91**	**.75**	**<.0001**
	34-35 (wave 5)	**-2.69**	**.51**	**<.0001**	**-2.30**	**.83**	**<.01**
	39-40 (wave 6)	**-2.42**	**.46**	**<.0001**	**-2.84**	**1.03**	**<.01**
Fraud		**B**	**S.E.**	**p**	**B**	**S.E.**	**p**
	17-18 (wave 1)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)
	20-21 (wave 2)	-.01	.19	.97	-.35	.50	.49
	24-25 (wave 3)	-.46	.26	.06	**-2.19**	**.47**	**<.0001**
	29-30 (wave 4)	**-2.92**	**.68**	**<.0001**	**-3.59**	**.72**	**<.0001**
	34-35 (wave 5)	**-1.74**	**.39**	**<.0001**	**-3.42**	**1.05**	**<.01**
	39-40 (wave 6)	-.31	.23	.18	-1.03	.55	.06

4.2. Bivariate models of the association between methamphetamine use and criminal offending outcomes adjusting for confounding and contemporaneous factors

Table 5 shows the parameter estimates, standard errors of estimate, probability values, and estimates of the odds ratio (OR) and 95% confidence intervals (CI) for the associations between each criminal offending outcome, and both "casual methamphetamine use" and "regular methamphetamine use". For each criminal offending outcome, the table presents three models in successive rows: the first row is the unadjusted bivariate association, while the second row shows the association adjusted for fixed confounding factors, and the third row shows the association adjusted for both confounding and contemporaneous covariate factors.

For the first model (top row for each outcome), it is clear that there was a consistently robust bivariate association between methamphetamine use and each outcome. For "casual use", estimates of the OR ranged between 2.44 and 4.31, while for "regular use" the ORs ranged from 5.75 to 26.22 (larger ORs are in part related to the relative scarcity of regular methamphetamine users; however, analytical power is retained as this is based on the full cohort size). What the results suggest, for example, is that those who reported using methamphetamine regularly had risks of using a weapon in a crime that were 26.22 times higher than those who did not use the substance.

Table 5 (second row) shows the associations between methamphetamine use and each criminal offending outcome, adjusted for the potentially confounding factors shown in Table 2. Table 5 shows that the inclusion of confounding factors in the model tended to reduce the magnitude of the associations, although these all remained statistically significant and robust. For "casual use", estimates of the OR ranged between 2.23 and 3.37, while for "regular use" the ORs ranged from 4.66 to 20.76. To illustrate the magnitude of the effect, adjustment for confounding reduced the risk of regular methamphetamine users using a weapon in a crime from 26.22 (please see paragraph above) to 20.76 times higher than non-users.

Table 5 (third row) shows the associations between methamphetamine use and each criminal offending outcome, adjusted for the potentially confounding factors shown in Table 2, and contemporaneous factors shown in Table 3. Table 5 also reports on a test of a direct comparison between the "casual use" group and the "regular use" group for the fully adjusted model (in cases where this is statistically significant, the "regular use" group has significantly higher rates of criminal offending than the "casual use" group). The results show, for example, the accounting for both time-invariant, and contemporaneous covariate factors reduced the risk for regular users of using a weapon in a crime from 20.76 (when just controlling for confounding factors) to 9.03 times higher than non-users.

Table 5 shows that the inclusion of confounding and contemporaneous factors in the model also reduced the magnitude of the associations, and in several cases the associations were no longer statistically significant, particularly for "casual use". For "regular use" however, the estimates of association again remained statistically significant and robust, with the exception of the property crime measure. For "casual use", estimates of the OR ranged between 1.21 and 2.10, with only theft remaining statistically significant, while for "regular use" the ORs ranged from 1.99 to 9.03. This pattern of results, in which the associations between regular methamphetamine use and different classes of crime remained statistically significant after control for both confounding factors and contemporaneous factors, suggests that regular (at least weekly) methamphetamine use plays a causal role in self-reported crime in the cohort.

Table 5: Associations between methamphetamine use and criminal offending outcomes, ages 16-40, before and after adjustment for confounding and covariate factors.

Outcome	Casual methamphetamine use (reference group = no use)				Regular methamphetamine use (reference group = no use)				Test of casual v. regular use
Theft	**B**	**S.E.**	**p**	**OR (95% CI)**	**B**	**S.E.**	**p**	**OR (95% CI)**	**X ^{2} (df)**
Model 1 (unadjusted)	1.46	.17	<.0001	4.31 (3.07-6.04)	2.39	.30	<.0001	10.93 (6.12-19.51)	
Model 2 (adjusted for confounding factors)	1.21	.21	<.0001	3.37 (2.25-5.04)	2.08	.35	<.0001	8.03 (4.01-16.09)	
Model 3 (adjusted for confounding factors and time-dynamic covariate factors)	.74	.22	<.0001	2.10 (1.37-3.22)	1.54	.37	<.0001	4.69 (2.27-9.70)	$X^2 (1) =$ 4.55, p < .05
Assault	**B**	**S.E.**	**p**	**OR (95% CI)**	**B**	**S.E.**	**p**	**OR (95% CI)**	**X ^{2} (df)**
Model 1 (unadjusted)	.89	.18	<.0001	2.44 (1.71-3.48)	1.75	.31	<.0001	5.75 (3.14-10.51)	
Model 2 (adjusted for confounding factors)	.80	.21	<.0001	2.23 (1.50-3.37)	1.54	.36	<.0001	4.66 (2.32-9.37)	
Model 3 (adjusted for confounding factors and time-dynamic covariate factors)	.37	.23	.099	1.45 (0.93-2.25)	1.04	.38	<.01	2.82 (1.35-5.92)	$X^2 (1) =$ 2.91, p = .09
Use of a weapon	**B**	**S.E.**	**p**	**OR (95% CI)**	**B**	**S.E.**	**p**	**OR (95% CI)**	**X ^{2} (df)**
Model 1 (unadjusted)	1.01	.31	<.01	2.74 (1.48-5.07)	3.27	.35	<.0001	26.22 (13.33-51.58)	
Model 2 (adjusted for confounding factors)	.92	.37	<.05	2.52 (1.21-5.22)	3.03	.46	<.0001	20.76 (8.40-51.29)	

	B	S.E.	p	OR (95% CI)	B	S.E.	p	OR (95% CI)	X^2 (df)
Model 3 (adjusted for confounding factors and time-dynamic covariate factors)	.23	.40	.576	1.25 (0.57-2.76)	**2.20**	**.50**	**<.0001**	**9.03 (3.31-24.65)**	**X^2(1) = 13.17, p < .001**
Property crime	**B**	**S.E.**	**p**	**OR (95% CI)**	**B**	**S.E.**	**p**	**OR (95% CI)**	**X^2 (df)**
Model 1 (unadjusted)	**1.12**	**.26**	**<.0001**	**3.04 (1.84-5.07)**	**2.17**	**.39**	**<.0001**	**8.80 (4.09-18.96)**	
Model 2 (adjusted for confounding factors)	**.91**	**.28**	**<.01**	**2.48 (1.43-4.28)**	**1.59**	**.49**	**<.01**	**4.91 (1.89-12.78**)	
Model 3 (adjusted for confounding factors and time-dynamic covariate factors)	.19	.30	.531	1.21 (0.66-2.19)	.69	.53	.196	1.99 (0.70-5.68)	X^2(1) = 0.86, p = .36
Fraud	**B**	**S.E.**	**p**	**OR (95% CI)**	**B**	**S.E.**	**p**	**OR (95% CI)**	**X^2 (df)**
Model 1 (unadjusted)	**1.41**	**.20**	**<.0001**	**4.10 (2.78-6.07)**	**2.49**	**.32**	**<.0001**	**12.09 (6.50-22.50)**	
Model 2 (adjusted for confounding factors)	**.87**	**.24**	**<.0001**	**2.39 (1.49-3.82)**	**1.95**	**.38**	**<.0001**	**6.99 (3.35-14.60)**	
Model 3 (adjusted for confounding factors and time-dynamic covariate factors)	.31	.26	.228	1.36 (0.82-2.25)	**1.11**	**.41**	**<.01**	**3.05 (1.37-6.80)**	X^2(1) = 3.68, p = .06

5. Discussion

It has long been acknowledged in the literature that there is a relationship between methamphetamine use and criminal offending, one that extends beyond the fact that the possession and supply of methamphetamine is a crime in most jurisdictions. However, much of the previous research in this area has been limited by the use of selected samples or special populations (such as prisoners or drug treatment patients), and relies primarily on the use of cross-sectional data [36]. The strength of the present study is that it draws on prospective longitudinal data from a representative birth cohort, born in 1977 and followed to age 40, covering the entire life course of the cohort to this point. In addition, the measures of criminal offending used in the present study were varied in nature, in order to discern whether there were any specific patterns to an association between methamphetamine use and particular kinds of offending. Finally, the wide range of measures of potential confounding factors, as well as factors that may mediate or "bridge" the associations between methamphetamine use and crime, allowed us to test whether these associations were likely to be causal. In this particular context, causality can be ascertained through the application of the Bradford Hill criteria for causality in observational studies [1], specifically in terms of the criteria pertaining to dose-response, robustness to control for confounding, and specificity of effect (control for contemporaneous covariate factors).

The data from the CHDS show that self-reported criminal offending, while not common throughout the cohort, was sufficiently common to explore associations between methamphetamine use and criminal offending. At the bivariate level, it is clear that the casual and regular use of methamphetamine were associated with a strong increase in the risk of reporting a range of crimes, including theft, assault, use of a weapon, property crime, and fraud. The dose-response profile in Table 1 shows that those who report using methamphetamine were considerably more likely to also report committing a crime, and those who reported using methamphetamine regularly were even more likely to report committing a crime. This dose-response profile is the first piece of evidence to support a causal conclusion in this analysis.

A second way of testing whether an exposure (in this case, methamphetamine use) and an outcome (in this case, criminal offending) is causal in nature, is to ensure that the association cannot be accounted for by factors that make the exposure more likely. This is known as confounding. In the present study, confounding was examined by controlling for the influence of factors such as family socio-economic positioning, family functioning, individual factors, abuse exposure, and mental health and behavioural issues in adolescence. The present analyses showed that while controlling for confounding did reduce the magnitude of the associations between methamphetamine use and criminal offending, these remained strong and statistically significant, suggesting that confounding factors alone could not account for this association. This is a second piece of evidence suggesting a causal role of methamphetamine in criminal offending.

A third means of testing the causal nature of an exposure and outcome is to control for the influence of factors and events that take place at the same time that the exposure and outcome were measured. It is possible, for example, for factors such as life stress or alcohol use disorder to mediate or "bridge" the association between methamphetamine use and criminal offending, increasing the likelihood that criminal offending will occur. If this was the case, the inclusion of such factors would reduce the magnitude of the association between methamphetamine use and criminal offending. This pattern of results was observed, but primarily only for regular methamphetamine use (with one exception for casual use, and one for regular use). Four of the five associations between criminal offending and regular methamphetamine use remained statistically significant and robust after control for confounding and contemporaneous factors.

This serves as a third and final piece of evidence suggesting that methamphetamine use, and in particular regular methamphetamine use, plays a causal role in criminal offending behaviour.

One limitation of the present approach is that it is theoretically possible that those who commit offences are more likely to use methamphetamine, perhaps through peer influence or other mechanisms we have identified as being potentially involved in the causal process. However, it is unlikely that this is the case, simply because the tendency to affiliate with "deviant others" in adolescence has been controlled for as part of the analysis. Another limitation of the present approach is that, while we have three pieces of evidence suggesting a causal relationship, our estimates of the strength of that relationship may be somewhat inaccurate, primarily due to the relatively small size of the cohort (approximately 1000 people), and the relative rarity of both methamphetamine use (this is particularly true for the measure of regular use) and criminal offending (as with most cohorts, a small number of people report committing the vast majority of the crimes). Each of these limitations shows the importance of replicating the present findings with other cohorts and in other settings.

The implications of the present findings are that, if there is indeed a causal role of methamphetamine use in criminal offending (as indicated by the present analyses), it is imperative to understand further the nature of this association, and the means by which it arises and manifests itself. We were unable to ascertain with our data, for example, the extent to which the criminal offending reported might have been linked to involvement in the drug trade, or in the acquisition of funds to pay for drugs (both of which we would expect are features of this association), or whether there is a more general process in which people who are using methamphetamine are more likely to commit crime due to a feature of methamphetamine intoxication, such as paranoia or the loosening of inhibitions. Further research is required to elucidate these questions in New Zealand.

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