Drug and Alcohol Dependence 228 (2021) 109030

Contents lists available at ScienceDirect

Drug and Alcohol Dependence

journal homepage: www.elsevier.com/locate/drugalcdep

Mortality among young people seeking residential treatment for problematic drug and alcohol use: A data linkage study

Sarita Bista [a,*], Sally Nathan [b], Patrick Rawstorne [b], Kieran Palmer [c], Mark Ferry [c], Megan Williams [a,d], Andrew Hayen [a,*]

[a] School of Public Health, Faculty of Health, University of Technology Sydney, Sydney, NSW, Australia
[b] School of Population Health, UNSW, Sydney, NSW, Australia
[c] Ted Noffs Foundation Sydney, NSW, Australia
[d] National Centre for Cultural Competence, University of Sydney, Sydney, NSW, Australia

ARTICLE INFO

Keywords:
Young people
Drug and alcohol use
Residential treatment
Mortality
Causes of death
Data linkage

ABSTRACT

Background: Young people with problematic alcohol and other drug (AOD) use are often referred to residential treatment. Subsequent mortality rates among this high-risk group is not known. This study estimates mortality rates and determines causes of death amongst young people referred to residential treatment in Sydney, Australia.

Design: Retrospective data linkage study. Data of young people (13–18 years) referred to a residential treatment service 2001–2015 (n = 3256) linked with Australian death registration data, and followed up to 16 years (2001–2016).

Methods: Mortality rates (CMRs) and standardised mortality ratios (SMRs, age-, gender-, calendar-year-adjusted) calculated using population mortality rates. Causes of death were analysed using ICD-10 codes for AOD-induced, AOD as contributory and non-AOD related causes.

Results: During follow-up of the cohort (28,838 person-years), 63 people died (71.4 % males; 48 % Indigenous; median age at death = 21.9 years; median follow-up = 5.1years), with 76 % dying before aged 25 years. Overall mortality (SMR = 4.91, 95 % CI: 3.8−6.2; CMR = 2.18/1000 person-years, 95 % CI: 1.7−2.8) was significantly higher than age-gender-matched general population, particularly in females (SMR = 9.55; males: SMR = 4.11; RR: 2.3, 95 % CI: 1.3–4.1). SMRs were not significantly different between treatment groups (SMRs>5.5) and non-attend group (SMR = 3.7) ($p = 0.359$). Two-thirds of deaths involved AOD, with AOD-induced deaths comprising 42 % and AOD as contributory for 22 % deaths. Overdose, mainly opioids (including opiates), suicide, and transport accidents were major causes of deaths.

Conclusion: Very high mortality rates, particularly among females, and the high incidence of overdose and suicide emphasise early screening for those at high-risk, targeted and culturally appropriate interventions, and maximised continuing after-care accessible to young people.

1. Introduction

Mental health and substance use disorder is a leading cause of morbidity and mortality worldwide (Whiteford et al., 2013). Globally, one in twenty deaths (over 3 million) were caused by harmful alcohol use in 2016 (World Health Organization, 2018) and deaths of an estimated 585,000 people were caused by drug use in 2017 (United Nations Office on Drugs and Crime, 2019). Links between substance use disorder (SUD) among adults and elevated suicide, homicide, poisoning, injuries, and infectious diseases are well established (Bartu et al., 2004; Darke et al., 2011; Degenhardt et al., 2009; Ericsson et al., 2014; Nyhlen et al., 2011; Schneider, 2009; Schulte and Hser, 2013). While there is higher premature mortality among adults with SUD (Abdul-Rahman et al., 2018; Åhman et al., 2018; Darke et al., 2011; Degenhardt et al., 2011, 2009; Lindblad et al., 2016; Mathers et al., 2013; Nambiar et al., 2015; Singleton et al., 2009), with mortality ranging from four to twelve times higher among treated people compared to the general population (Finney et al., 1999 Apr 15:30−49), there is limited evidence on mortality of

* Corresponding author.
E-mail address: Andrew.hayen@uts.edu.au (A. Hayen).

https://doi.org/10.1016/j.drugalcdep.2021.109030
Received 14 April 2021; Received in revised form 27 July 2021; Accepted 27 July 2021
Available online 17 September 2021

young people referred to treatment for problematic alcohol and other drug (AOD) use. The study of the relationship between young people's AOD use and related deaths has become increasingly important, given the increase of drug-induced deaths reported, particularly drug overdose, and drug-influenced suicide and transport accidents among young people (15–39 years) (Australian Bureau of Statistics, 2016; United Nations Office on Drugs and Crime, 2018) (please see the methods section for definitions of drug-induced and drug-influenced deaths).

Surveys in the general population across countries have found that health consequences from drug use are higher among young people (10–24 years) than older people (United Nations Office on Drugs and Crime, 2018). Compared with adults, the developing adolescent brain is more at risk to the harmful effects of problematic AOD use, and early initiation is associated with poorer mental and physical health (Brown et al., 2000; Weinberg et al., 1998; Wetherill and Tapert, 2013). Studies have linked problematic AOD use by young people with multiple adverse outcomes during their first decade of adult life, including continued problematic AOD use (Evans, 2015; Larm et al., 2015, 2008; Larm et al., 2010; McCarty et al., 2004), health problems (Mertens et al., 2007; Schulte and Hser, 2013), suicidal behaviour (Bukstein et al., 1993; Pompili et al., 2012), and death (Hodgins et al., 2009; Larm et al., 2015, 2008; Molero Samuelson et al., 2010). Young people with problematic AOD use are different from adults in many ways, including that treatment-seeking young people are more likely to use multiple substances, with the majority using a combination of alcohol and cannabis as their primary drugs, less involvement with opiates, and more likely to be referred by juvenile justice systems (Winters et al., 2007, 2000). Young people presenting for treatment are also more likely to have co-occurring psychiatric diagnoses than adults (Brown et al., 1996; Crowley et al., 1998; Grella, 2006; Wei et al., 2011). These differences may impact their longer term clinical course (Winters et al., 2007) and raise important implications for the provision of specialised treatment for young people that address their multiple and complex needs (Muck et al., 2001)

Residential treatment within a Therapeutic Community (TC) approach is one of the well-regarded specialised treatments in several countries including the United States (US) and Australia to address adolescent AOD problems and other related issues, and is a modality of treatment available to young people worldwide, including in Australia (Jainchill, 2000; Muck et al., 2001; Nathan et al., 2020, 2016b; Tripodi, 2009). Young people in residential treatment in Australia and the US have been found to have complex histories, including trauma and co-morbid psychiatric conditions (Dixson et al., 2018; Nathan et al., 2016a; Neumann et al., 2010; Vourakis, 2005), family histories of problematic AOD use (Blood and Cornwall, 1994), younger age of initiation (Fickenscher et al., 2006), a history of arrests (Vourakis, 2005), and experience of sexual and physical abuse (Dixson et al., 2018; Neumann et al., 2010). Empirical evidence suggests that TCs are successful for treating a number of AOD and psychosocial issues common among young AOD users (Hawke et al., 2000; Morral et al., 2004). Studies on TC treated young people, however, have shown positive treatment effects on substance use, health and psychological functioning in the short-term only up to 12 months (e.g., Agosti and Levin, 2007; Albertella and Norberg, 2012; Dasinger et al., 2004; Godley et al., 2001; Gossop et al., 1999; Hambley et al., 2010; Hawke et al., 2000; Hser et al., 2001; Jainchill et al., 2000; Morral et al., 2004). Long-term outcome studies have found mixed results, some with positive treatment effects on substance use lasting beyond the first year (Brown, Ramo & Anderson 2011), with others showing erosion of positive effects on substance use and psychological functioning after 12 months and no evidence of positive effects in the long-term (Edelen et al., 2010; Jainchill et al., 2005). However, none of these long-term studies has examined treatment effects on mortality.

Among a few mortality studies of AOD using young people from other treatment modalities, only two long-term studies (Oyefeso et al., 1999; Zabransky et al., 2011) have estimated crude mortality rates (CMR) and standardised mortality ratios (SMR) using national death registry data. Both studies found substantially elevated mortality compared to the general population, with SMR of 12.3 among a cohort of drug-dependent young people in England and Wales (Oyefeso et al., 1999) and 14.4 among young people treated for injecting drug use in Prague (Zabransky et al., 2011). Another four Swedish studies investigated long-term outcomes of young people treated from a clinic for AOD use, using linked national registry data for over 25 years and matched general population data (Hodgins et al., 2009; Larm et al., 2015, 2008; Molero Samuelson et al., 2010). These studies found that treatment-seeking young people had increased risks of death, hospitalisations for mental and physical disorders, problematic AOD use, and criminal involvement as adults.

Despite increased risk of premature death among treatment-seeking young people being documented in a few previous studies, studies examining mortality among young people who sought residential treatment are lacking globally, and there are no Australian studies. The purpose of this study is to examine mortality of young people referred to an Australian residential treatment program for problematic AOD use. Our primary aims are to: 1) estimate mortality among residential treatment-seeking young people for problematic AOD use, and compare mortality with the general population; 2) examine mortality patterns by demographic, treatment, and pre-treatment AOD use and mental health characteristics; 3) compare mortality between treatment non-attenders and treatment groups, and between Aboriginal and non-Indigenous groups; and 4) analyse causes of death.

2. Methods

2.1. Study design and participants

This study examined mortality among young people (aged 13–18) referred to residential treatment for problematic AOD use. The study population comprised all young people referred and assessed at the Ted Noffs' Foundation treatment program (Program for Adolescent Life Management - PALM) in New South Wales (NSW) and the Australian Capital Territory (ACT), Australia, from 2001 to 2016. The PALM database consisted of 3639 young people (males and females). Exclusion criteria included: assessment date (or admission date if assessment date was missing) not within the period January 2001- June 2015 if not in 13–18 age group and if both assessment and admission dates were missing. Of 3639 clients, we excluded 383 subjects (352 with assessment dates not within January 2001–June 2015 period, and 31 meeting at least one of the other exclusion criteria) (Fig. 1).

The final sample for this study comprised 3256 young people, which included three treatment-attend groups for comparison: (a) '30 days + completers' (n = 1348, 42 %), - who attended treatment staying over 30 days up to three months, (b) 'non-completers' (n = 762, 23 %), who stayed at treatment for a month or less and did not complete treatment (4−30 days), and (c) 'non-attenders' (n = 1146, 35 %), who were referred and assessed but did not attend treatment or attended only up to 3 days (0−3 days). Although detailed data were not available on reasons for non-admission among non-attend group, reasons for non-admission generally included: being refused bail (and therefore unable to enter treatment), loss of interest (Dixson et al., 2018), or assessed as not being eligible.

The study was approved by all relevant ethics committees (the NSW Population and Health Services Ethics Committee; Aboriginal Health and Medical Research Council; ACT Health Ethics Committee).

2.2. Setting

PALM is a modified therapeutic community (TC) residential treatment program of up to three months and offers three years of aftercare for young people with problematic AOD use. PALM follows a harm reduction approach with a holistic focus on various aspects of a person's

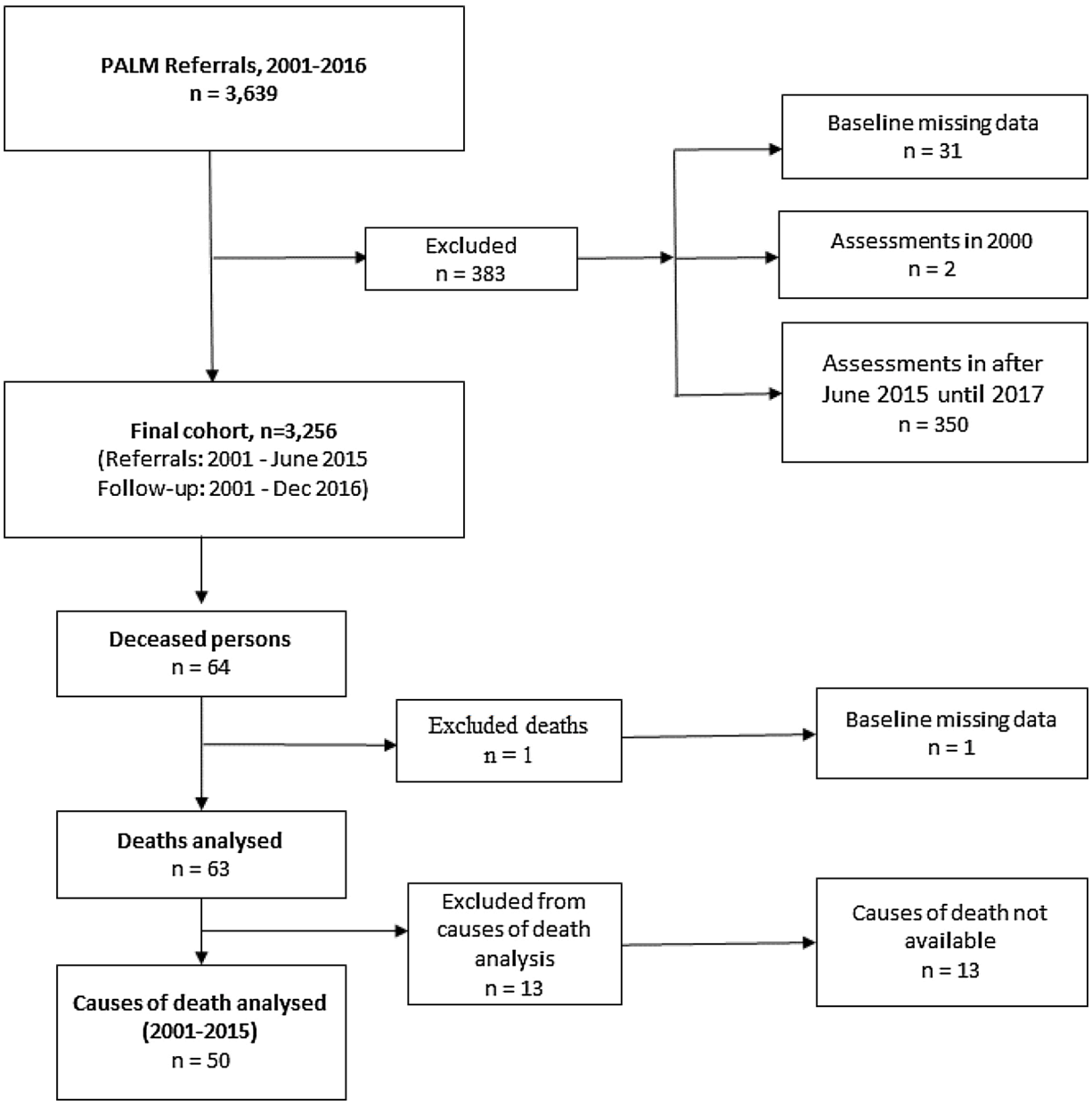

Fig. 1. Flowchart of participants in the study cohort and mortality analysis, 2001-2016.

life in addition to problematic AOD use. The treatment program details were published previously (Foster et al., 2010; Nathan et al., 2016b).

Participants were referred by the juvenile justice system/case workers/clinicians, or by self/family/friends, and assessed by expert service staff for their treatment eligibility using the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) criteria for pre-treatment substance abuse/dependence. Eligibility was mainly based on those demonstrating significant problematic use of any drug or alcohol over the past 12 months meeting DSM-IV substance abuse/dependence criteria. The interviewer-administered assessment questionnaire collected other baseline information on demographic, socio-economic status, AOD use, and comorbid mental health and behavioural problems. Brief Symptom Inventory (BSI) 53-items (Derogatis, 1993) was administered to assess comorbid psychiatric problems distressing/bothering client during the last seven days including day of assessment.

2.3. Data sources and linkage

The NSW Centre for Health Record Linkage (CHeReL) linked PALM data to mortality data from the death registry authorities in NSW and ACT, which provided deaths and their causes in the study cohort. CHeReL used probabilistic record linkage (based on full name, address, birthdate, and sex).

All deaths in Australia are coded by the Australian Bureau of Statistics (ABS) using the ICD-10 (International Classification of Diseases 10th Revision) coding system, which identifies the underlying cause of death and contributory factors (Australian Bureau of Statistics, 2017a).

Based on ICD-10, the ABS has defined 'drug-induced' death where a drug is the underlying cause of death, and a 'drug-related' death where drugs are mentioned as the contributory cause but deaths were due to other underlying causes. ABS drug-induced deaths included overdose deaths of all intents including accidents, suicide, homicide, and mental and behavioural conditions caused by drug abuse (e.g. addiction) and chronic health conditions such as drug induced circulatory diseases. The

ICD-10 codes for drug-induced deaths were: F11-F16; F19; F55; X40-X44; X60-X64; X85; Y10-Y14. This definition excludes alcohol, tobacco and volatile solvents (Australian Bureau of Statistics, 2016). For alcohol-induced deaths where alcohol was an underlying cause of death, the ICD-10 codes were: E24.4; F10; G31.2; G62.1; I42.6; K29.2; K70; K73; K74; K85.2; K86.0; X45; X65; Y15 (Australian Bureau of Statistics, 2017a). In alcohol-related deaths, alcohol was mentioned as a contributory cause to death.

Based on these definitions, we categorised causes of deaths into three groups: (a) drug/alcohol as underlying cause; (b) drug/alcohol as a contributory factor; (c) non-AOD related cause. Causes of deaths in the cohort were available for 50 deaths from 2001 to 2015 (Fig. 1).

2.4. Statistical analysis

The primary outcome measure was all-cause mortality. We calculated person-years (PY) at risk for each person using the follow-up period (1 January 2001 to 31 December 2016) where follow-up started from the first assessment date (or first admission date if assessment date was missing) until the date of death or study end date (31 December 2016).

CMRs were calculated using a person-time method. Age-, sex- and calendar-year-adjusted SMRs were estimated using an indirect method (observed deaths/expected deaths). The expected number of deaths was calculated using age-, sex- and calendar-specific death rates for NSW 2001–2016 (Australian Bureau of Statistics, 2017b). The 95 % confidence intervals for CMRs and SMRs were calculated based on the Poisson distribution. CMRs and SMRS were also calculated according to demographic, Indigenous status, treatment-attend groups, and pre-treatment characteristics. For selected characteristics, we compared SMRs between groups using likelihood ratio tests for homogeneity. Analyses were conducted in SAS and R V3.5.3.

For the pre-treatment substance use measure, the DSM-IV substance dependence score was calculated using a seven-item-questionnaire with value of one for each item responded. The substance dependence criterion was met if total score was ≥3. For the pre-treatment mental health measures, we used the Brief Symptoms Inventory (BSI), which included items for nine primary symptom dimensions (Somatisation, Obsession-Compulsion, Interpersonal Sensitivity, Depression, Anxiety, Hostility, Phobic Anxiety, Paranoid Ideation, Psychoticism) plus four additional items (Derogatis, 1993). We calculated three global indices from BSI: Global Severity Index (GSI), which combines information on number of symptoms and the intensity of distress; Positive Symptom Total (PST), number of symptoms experiencing (non-zero responses); Positive Symptom Distress Index (PSDI), sum of values of items receiving non-zero responses divided by PST, providing average level of distress experienced. These raw scores were converted to T-Scores using tables for adolescent non-patient norms for males and females with GSI T-Scores ≥63 considered clinical (Derogatis, 1993).

3. Results

3.1. Study cohort characteristics

Table 1 presents the sample characteristics by gender. The study cohort (n = 3256; 73 % male and 43 % Aboriginal and/or Torres Strait Islander – Aboriginal) had a median age of 16.8 years at referral. The cohort was followed for up to 16 years (2001–2016) contributing 28,838 PY, with a median follow-up of 8.9 years. Around half (47 %) reported current poly-drug use at baseline, with common drugs being cannabis, tobacco, alcohol, amphetamines, ecstasy/related drugs, and hallucinogens. DSM-IV substance dependence scores showed that 65 % (n = 1646) of respondents having a high severity of dependence (score >5), with a larger proportion of females, compared to males, having dependence score >5 (74 % vs 62 %; $P < 0.0001$). Over a third (38 %, n=957) of the respondents reported ever attempting suicide or self-harming (n=984; 41 %), almost two thirds (n=1593, 64 %) reported experiencing physical assault by someone known and 20 % (n=488) reported sexual assault by someone known. Greater proportions among females, compared to among males, were likely to report using poly-drug (94 % vs 91 %; $P = 0.0328$), attempting suicide (47 % vs 23 %; $P < 0.0001$) or self-harm (47 % vs 24 %; $P < 0.0001$), experiencing

Table 1
Baseline cohort characteristics at treatment assessment by gender, 2001-2015 (N = 3256).

	Male (n = 2367)	Female (n = 889)	Total (N = 3256)
Median age at entry assessment (years)	16.9	16.5	16.8
Median days of treatment (n = 2266 excluding days = 0; male = 1642, female = 624)	40	45	41
Median follow-up years	8.9	9.2	8.9
Indigenous status			
Aboriginal	1085 (46 %)	310 (35 %)	1395 (43 %)
Non-Indigenous	1282 (54 %)	579 (65 %)	1861 (57 %)
Treatment-attend groups			
Non-attenders (0–3 days)	839 (35 %)	307 (35 %)	1146 (35 %)
Non-completers (4–30 days)	557 (24 %)	205 (23 %)	762 (23 %)
30 days + completers (>30 days)	971 (41 %)	377 (42 %)	1348 (41 %)
Age at referral (years)			
13–14	175 (7%)	110 (12 %)	285 (9%)
15–16	1118 (47 %)	467 (53 %)	1585 (49 %)
17–18	1073 (45 %)	312 (35 %)	1385 (43 %)
DSM-IV Substance Dependence Score (≥3) (respondents: n = 2532)	*(n = 1839)*	(n = 693)	
3–5	706 (38 %)	180 (26 %)	886 (35 %)
6–7	1133 (62 %)	513 (74 %)	1646 (65 %)
Current drug use - at assessment [a]			
Cannabis	1044 (44 %)	396 (45 %)	1440 (44 %)
Tobacco	1000 (42 %)	405 (46 %)	1405 (43 %)
Alcohol	379 (41 %)	356 (40 %)	735 (23 %)
Amphetamines	462 (20 %)	219 (25 %)	681 (21 %)
Ecstasy and related drugs	431 (18 %)	162 (18 %)	593 (18 %)
Hallucinogen	145 (6%)	63 (7%)	208 (6%)
Cocaine	113 (5%)	51 (6%)	164 (5%)
Opioids[b]	41 (2%)	32 (4%)	72 (2%)
Poly-drug use - last 3 months (respondents: n = 1678)			
Yes	1107 (91 %)	428 (94 %)	1535 (47 %)
No	115 (9%)	28 (6%)	143 (4%)
Mental health issues[a]			
Attempted, end life- ever	543 (23 %)	420 (47 %)	963 (30 %)
Attempted, end life- last 3 months	178 (8%)	151 (17 %)	329 (10 %)
Self-harmed - ever	572 (24 %)	417 (47 %)	989 (30 %)
Self-harmed-last 3 months	175 (7%)	151 (17 %)	326 (10 %)
Trauma - experienced/witnessed [a]			
Physical assault-known	1091 (46 %)	511 (57 %)	1602 (49 %)
Physical assault-stranger	926 (39 %)	268 (30 %)	1194 (37 %)
Sexual assault-known	170 (7%)	318 (36 %)	488 (15 %)
Sexual assault-stranger	87 (4%)	164 (18 %)	251 (8%)
Verbal abuse	662 (28 %)	409 (46 %)	1071 (33 %)
BSI Global Severity Index (respondents: n = 2356)	*(n = 1696)*	*(n = 660)*	
GSI T-score <63	1403 (83 %)	354 (54 %)	1757 (75 %)
GSI T-score ≥ 63	293 (17 %)	306 (46 %)	599 (25 %)

[a] Percentage in each category was calculated out of the total cohort sample (by sex, and overall), and also the percentages are not mutually exclusive and therefore do not add to total (100 %).

[b] Opioids include heroin, opiate-based analgesics including codeine, morphine and oxycodone, and synthetic opioid drugs such as methadone and fentanyl (not including legally obtained methadone).

physical (57 % vs 46 %; $P < 0.0001$), sexual (36 % vs 7%; $P < 0.0001$) or verbal assaults (46 % vs 28 %; $P < 0.0001$) at baseline. A quarter (25 %) of BSI respondents (n=2357) reported clinical distress levels (global severity index (GSI) T-score ≥63), with greater proportions among females reporting clinical distress level (46 % vs 17 %; $P < 0.0001$) (Table 1).

3.2. Overall mortality rates

During follow-up, 64 people died. We excluded one death from further analyses because of missing baseline information. Table 2 presents mortality rates. The overall crude mortality rate (CMR) was 2.15 deaths per 1000 person-years (95 % confidence interval (CI):1.68−2.76), substantially higher than the annual NSW age-specific crude death rates during the study period (annual rate <1/1000 NSW population). CMRs were similar among men and women (>2). The overall SMR was almost five times higher than the general population (4.91, CI: 3.8−6.2). The SMRs were significantly higher in females (9.55, CI: 5.8−14.7) than males (4.07, CI: 3.0–5.38) ($P = 0.005$). There was no evidence of difference between the Aboriginal group and the non-Indigenous group (SMR: 5.6 vs. 4.4; $P = 0.338$). Mortality rates were similar for all treatment groups (non-completers: SMR=5.6; 30 days+ completers: SMR=5.5; and non-attend group: SMR=3.7; $P = 0.359$). The standardised mortality rates were substantially elevated for people who had clinically significant mental health with GSI T-Score ≥63 (SMR >6.6) compared to the general population.

3.3. Characteristics of decedents

Of the 63 deceased people, 45 were males (71 %) and 48 % identified as Aboriginal (Table 2). The median age at death was 21.9 years (IQR: 19.2–24.3), with 48 (76 %) deaths occurring before age 25. Almost half (46 %) attended treatment for >30 days and another 27 % had experienced some treatment (≤30 days). A quarter (25 %) of the deceased had reported pre-treatment poly-drug use, with cannabis, alcohol, amphetamines, and ecstasy being the most common substances used. Over a third reported ever attempting suicide (37 %) and ever self-harming (30 %), with many experiencing/witnessing physical assault (59 %) and/or sexual assault (21 %) by someone known, and verbal abuse (29 %) (Table 2). Twelve decedents had high pre-treatment distress levels (GSI T-Score≥63).

3.4. Causes of death

Of the 63 deaths, the causes of 50 deaths (males: 68 %; females: 32 %) were available for analysis (Table 3). The other 13 deaths (6 deaths occurred in the ACT and 7 deaths occurred after June 2015), for which cause of death data were not available at the time of the data linkage due to time lag or cases under investigation by the coroner.

3.4.1. Drugs and alcohol as underlying causes of death

Out of 50 deaths, 21 (42 %) were directly attributed to drugs or alcohol (Table 3). Of these 21 deaths, 17 (81 %) had multiple drugs involved, and 18 (90 %) deaths were from accidental overdose, where opioid (including opiates) overdose (n = 15) was the dominant cause (methadone and/or heroin poisoning (n = 10) and other opioids). Female participants were more likely to use multiple drugs and more likely to die due to accidental overdose than males (63 % among females vs 24 % among males). Aside from opioids, depressants (benzodiazepines, n = 8), anti-depressants (n = 8) and stimulants (amphetamines, cocaine, and other psychostimulants (n = 7)) were the other drugs causing death (Table 3).

3.4.2. Drugs and alcohol as contributing factors of death

Out of 50 deaths, 11 (22 %) were attributed to external causes such as transport accidents and suicide, where alcohol or alcohol in combination with hallucinogens and other psychoactive drugs (unspecified) were present at death as contributing factors (Table 3).

3.4.3. Non-drug and non-alcohol deaths

There were 18 (36 %) deaths due to external causes where no drugs or alcohol were involved at death. Suicide was the most common cause (n = 8), particularly among young men (n = 6) followed by transport accidents and assaults (Table 3).

4. Discussion

As the first long-term follow-up study in Australia of mortality among young people referred to residential treatment, this study provides evidence on mortality outcomes following residential treatment, reported as one of the effective treatment programs for young people' problematic AOD use (Jainchill et al., 2000, 2005). We found an increased rate of death of about five times than in the general population of the same age group, and more than nine times in females and more than 5 times among those who identified as Aboriginal. There was no evidence of differences in mortality rates among the treatment-attend groups. Almost a third of the study cohort had pre-treatment suicide attempts or self-harm and over half had experienced or witnessed physical or sexual assault. Around two thirds of deaths (64 %) had drug or alcohol involved directly or indirectly. Accidental overdose, mainly opioid overdose, was the major cause of death followed by suicide and transport accidents.

The overall SMR in this study was consistent with two Australian studies on mortality of opioids users (Darke et al., 2011; Degenhardt et al., 2009), and a Swedish study (Nyhlen et al., 2011). However, overall CMR was substantially lower than these studies. This may reflect smaller number of opioids users at baseline (2% only) in our study. Females and younger participants (<25 years) had substantially higher SMRs than males and older clients. Females saw significantly higher mortality rates of more than two-fold than male participants (RR: 2.3, 95 % CI: 1.3–4.1). An explanation for higher mortality rates for females is attributable primarily to the lower mortality rates among the female general population (Darke et al., 2011; Degenhardt et al., 2011). Several other studies also found higher SMR in females than males (Arendt et al., 2011; Degenhardt et al., 2011; Evans et al., 2012; Gjersing and Bretteville-Jensen, 2014; Lindblad et al., 2016; Oyefeso et al., 1999; Stenbacka et al., 2010). However, there is a paucity of studies identifying female-specific predictors of AOD-related deaths. Some studies suggest that females are more likely to abuse drugs or alcohol than males, and abusing drug or alcohol elevates mortality (Degenhardt et al., 2011; Lindblad et al., 2016) including suicides (Pompili et al., 2012; Schneider, 2009). Female young people using drugs are likely to also be poly-drug users, in unstable living arrangements and with problematic family situations (Dixson et al., 2018). Consistent with these studies, we found that a larger proportion of female participants than male counterparts from treatment groups reported pre-treatment poly-drug use, greater substance use dependence (DSM-IV >5), suicidal attempts or self-harm, physical or sexual or verbal assault experiences, and almost half (46 %) of female BSI respondents reported clinically significant distress level (GSI T-score≥63). Those with such comorbidities or higher substance dependence showed substantially elevated mortality rates (SMRs) compared to the general population.

Similarly, we found that SMRs for the Aboriginal young people were greater than five, although there was no evidence of difference compared to non-Indigenous group. Almost half of deaths (48 %) occurred among the Aboriginal people. Over a third (>34 %) of the Aboriginal participants had reported attempting suicide and/or self-harm, and around two thirds experienced or witnessed physical assaults by someone known. This reflects the vulnerability of Aboriginal young people with comorbid psychiatric and trauma histories. Evidence shows that self-harm and suicide rates among Aboriginal and/or Torres Strait Islander population are among the highest in the world,

Table 2
All-cause mortality (CMR and SMR) of study cohort by demographic and pre-treatment characteristics, 2001–2015.

	Study cohort (%)	Observed deaths (%)	Expected deaths	Person-years	CMR/1000 Person-years (95 % CI)	SMR (95 % CI)	P-value for homogeneity
Total sample (N)	3256	63	12.82	28,838	2.18 (1.7–2.8)	4.91 (3.8–6.2)	
Male	2367 (73 %)	45 (71 %)	10.9	20928.58	2.15 (1.6–2.9)	4.11 (3.0–5.4)	0.005
Female	889 (27 %)	18 (29 %)	1.9	7909.66	2.27 (1.4–3.6)	9.55 (5.8–14.7)	
Aboriginal	1395 (43 %)	30 (48 %)	5.3	11842.67	2.53 (1.8–3.6)	5.62 (3.8–7.9)	0.338
Non-Indigenous	1861 (57 %)	33 (52 %)	7.5	16995.57	1.94 (1.4–2.7)	4.41 (3.0–6.1)	
Treatment-attend groups							
Non-attenders (0–3 days)	1146 (35 %)	17 (27 %)	4.5	10160.61	1.67 (1.4–2.7)	3.74 (2.2–5.8)	
Non-completers (4–30 days)	762 (23 %)	17 (27 %)	3	6653.17	2.55 (1.6–4.1)	5.64 (3.4–8.7)	0.359
30 days + completers (>30 days)	1348 (42 %)	29 (46 %)	5.3	12024.46	2.41 (1.7–3.5)	5.51 (3.7–7.7)	
Age at referral (years)[a]							
13–14	285 (9%)		–	–	1.20 (0.3–3.7)	3.25 (0.8–8.4)	0.232
15–16	1585 (49 %)		–		1.72 (1.2–2.6)	4.06 (2.6–5.9)	
17–18	1385 (42 %)	36 (57 %)-	–	12394.24	2.90 (2.1–4.0)	6.02 (4.3–8.2)	
Deaths by follow-up time							
< 5 years	–	31 (49 %)	6.12	15063.49	2.05 (1.4–2.9)	5.14 (3.5–7.2)	
5–9 years	–	19 (32 %)	4.74	9863.18	1.93 (1.2–3.0)	4.03 (2.5–6.1)	0.537
10–14 years	–	12 (18 %)	2.03	3797.81	3.16 (1.8–5.6)	5.98 (3.2–10)	
DSM-IV Substance Dependence Score (≥3) (respondents: n = 2532; deaths n = 53)[b]							
3–5	886 (35 %)	12 (23 %)	3.1	6890.4	1.74 (0.9–3.0)	3.87 (2.1–6.5)	0.08
6–7	1646 (65 %)	41 (77 %)	6.1	14071.5	2.91 (2.1–3.9)	6.7 (4.9–9.0)	
BSI Global Indices (respondents: n = 2356; deaths n = 43)[a,b]							
Global Severity Index (GSI)							
GSI T-score <63 (Males)	1403 (60 %)	25 (58 %)	5.53	10968.65	2.28 (1.5–3.4)	4.52 (3.0–6.5)	0.345
GSI T-score ≥ 63 (Males)	293 (12 %)	8 (19 %)	1.19	2333.77	3.43 (1.7–6.8)	6.72 (3.1–12.5))	
GSI T-score <63 (Females)	354 (15 %)	–	–	–	2.23 (1.0–4.9)	9.75 (3.9–19.7)	0.543
GSI T-score ≥ 63 (Females)	306 (13 %)	–	–	–	1.55 (0.6–4.1)	6.61 (2.1–15.4)	
Positive Symptom Total (PST)							
PST T-score <63 (Males)	1468 (62 %)	25 (58 %)	5.82	11537.56	2.17(1.5–3.2)	4.29 (2.8–6.2)	0.078
PST T-score ≥ 63 (Males)	212 (9%)	8 (19 %)	0.86	1684.15	4.75 (2.4–9.5)	9.27 (4.2–17.2)	
PST T-score <63 (Females)	404 (17 %)	–	–	–	1.87 (0.8–4.2)	8.09 (3.2–16.4)	0.95
PST T-score ≥63 (Females)	252 (11 %)	–	–	–	1.96 (0.7–5.2)	8.42 (2.6–19.6)	
Positive Symptom Distress Index (PSDI)							
PSDI T-score <63 (Males)	1361 (58 %)	25 (58 %)	5.43	10721.5	2.61 (1.8–3.8)	5.16 (3.5–7.3)	0.578
PSDI T-score ≥ 63 (Males)	319 (14 %)	8 (19 %)	1.26	2500.22	2.0 (0.8–4.8)	3.97 (1.4–8.5)	
PSDI T-score <63 (Females)	328 (14 %)	–	–	–	2.34 (1.1–5.2)	10.08 (4–20.4)	0.482
PSDI T-score ≥ 63 (Females)	328 (14 %)	–	–	–	1.49 (0.6–3.9)	6.44 (2.0–14.9)	

[a] Observed deaths and corresponding expected deaths and PY in the cells are not presented because of fewer than five deaths.
[b] Percentages were out of those who responded to the respective questions and the deaths in each group.

Table 3
Causes of death (ICD-10) in the study cohort, 2001–2015 (n = 50).

A. Causes of death (ICD-10)		Number of deaths (n = 50)
Broad causes	Specific causes	
1. Drug- or alcohol-induced (underlying) causes of death		*21 (42 %)*
Overdose of opioids[a] only or opioids in combination with psychostimulants or depressants or other drugs or alcohol	Accidental poisoning of opioids (methadone only) and opioids (methadone, heroin) in combination with other opioids (codeine, morphine), benzodiazepines, amphetamines, cocaine, other psychostimulants (unspecified), antidepressants (unspecified), cannabis, antipsychotics (unspecified), and alcohol.	15
Overdose of other non-opioids drugs (such as psychostimulants or depressants or other drugs) in combination or with alcohol	Accidental poisoning of combination of non-opioid drugs such as: benzodiazepines, amphetamines/ psychostimulants (unspecified), cannabis, antiepileptic (unspecified), and alcohol.	6
2. Drugs and/or alcohol as contributing factors of death[b]		*11 (22 %)*
External Causes of death	Transport accident	
	Suicide, drowning, falls and natural causes	
Substances present at death:		
Psychoactive drugs only or in combination with alcohol	Hallucinogens, other psychoactive drugs (unspecified), other addictive drugs (unspecified), and alcohol	
Alcohol	Alcohol only	
3. Non-drug or non-alcohol related deaths		*18 (36 %)*
External Causes of death	Suicide	8
	Transport accident, assaults, natural causes, and other causes	10

B. Overall number of deaths[c] by substances present at death (from drug-/alcohol-induced and drug/alcohol contributed deaths)		
Drug classes	Main drug types found at death (in combination with other drugs types)	Number of deaths[c]
Opioids	Methadone, heroin, other opioids including codeine and morphine	15
Depressants	Benzodiazepines	8
Stimulants	Amphetamines, cocaine, and other psychostimulants (unspecified)	7
Antidepressants	Antidepressants (unspecified) and other multiple drugs (unspecified)	8
Hallucinogens and other psychoactive drugs (unspecified)	Hallucinogens, cannabis, and other psychoactive drugs (unspecified)	7
Alcohol	Alcohol	13

[a] ICD-10 codes for poisoning by opioids include opium (T400), heroin (T401), opiate-based analgesics including codeine, morphine, and oxycodone (T402), methadone (T403), and synthetic opioid drugs such as buprenorphine, fentanyl, tramadol (T404), and unspecified/other opioids (T406) (Australian Bureau of Statistics, 2016).

[b] Smaller values in the cells are not presented.

[c] The number of deaths according to drug classes and drug types are not mutually exclusive, and therefore, the figures do not match the total number of deaths due to drug and/or alcohol as underlying and contributing causes.

particularly among young people (<25 years) (Dickson et al., 2019; Dudgeon et al., 2016; Nathan et al., 2020). Aboriginal young people attending this residential treatment program constituted slightly less than half (43 %) of the study cohort, compared to <3% in the general community. A recent study (Nathan et al., 2020) has reported that Aboriginal young people attending PALM residential treatment for AOD use were likely to face a multitude of pre-treatment challenges including unstable living, court involvement, less engagement in employment or study, and self-harm or suicide attempts. PALM's Therapeutic Community offers a holistic and multidimensional approach to treatment. However, these findings suggest that detecting risk factors and identifying effective and culturally targeted interventions by addressing the underlying multidimensional complexities related to socio-economic and historical factors among Aboriginal participants remains an important objective for residential treatment programs and early intervention at the individual and societal level to address these challenges.

We did not find differences in mortality rates when comparing the treatment groups (30 days + completers and non-completers) and the non-attend group. Although treatment retention or longer time in treatment have been shown to have positive outcomes including significantly decreased relapse rates among young people (Hser et al., 2001; Jainchill et al., 2000), our findings showed no significant differences in mortality outcomes between those staying a longer time in treatment (> 30 days) and those with a shorter stay (non-completers) or no treatment (non-attenders). The lack of observed difference in mortality among treatment groups may be due to confounding by indication as the young people in the treatment groups were more vulnerable young people with greater substance use severity and comorbid psychiatric issues requiring complex and targeted care, and therefore there may not be a reduction in mortality following discharge for those who completed treatment (Dasinger et al., 2004; Dixson et al., 2018; Nathan et al., 2016a, 2020; Neumann et al., 2010). Studies have demonstrated that young people in treatment often have high rates of comorbid psychiatric conditions, experience of sexual and physical abuse including several other social and family issues (Blood and Cornwall, 1994; Dixson et al., 2018; Fickenscher et al., 2006; Neumann et al., 2010; Vourakis, 2005) as we found in the current study. Young people with comorbid psychiatric problems are more likely to relapse after AOD treatment (McCarthy et al., 2005). However, evidence suggests that there are heterogeneity in comorbidity and AOD use among young people, and therefore different subtypes of comorbid young people may respond differently to AOD use treatment (Grella et al., 2001). Treatment approaches for this population therefore need to engage with this complexity. These findings highlight the importance of targeted treatment approaches as well as continuing care or aftercare that need to reach out to these young people for a longer period of time post-treatment. Studies show that continuing support that promotes abstinence self-efficacy (Jason et al., 2007) and adherence to continuing care are associated with reductions in substance use and related problems and slowing relapse process (Garner et al., 2007). PALM offers up to three years of aftercare or continuing care through its Continual Adolescent Life Management (CALM) program providing support package to PALM participants with their ongoing substance use, mental health, and other related issues. However, the program routinely follows up young people at three months post-discharge to only those who stayed at least 30 days at treatment (Nathan et al., 2020). A large proportion of PALM treatment participants, particularly those who stayed less than 30 days, seem to have missed out on the benefits of CALM program. The implication of the present research findings of increased mortality rates but not different between 30 days + completers and non-completers indicates that maximising aftercare and continuing care to all participants may be the key to reduce post-treatment substance use, relapse, self-harm and deaths. This may be possible by improving the programs and resources for better engagement with the participants and promotion of targeted continuing care approaches to reach out a larger proportion of young people for a longer period of time post-treatment.

We found that two-thirds of deaths (64 %) had AOD as underlying cause or contributing factors. Consistent with Australian studies on adults (Bartu et al., 2004; Darke et al., 2011; Degenhardt et al., 2009, 2005), we found that accidental overdose, mainly opioids (methadone, heroin, or codeine/morphine), was the dominant cause of drug-induced deaths followed by benzodiazepines and amphetamines including other unspecified psychostimulants, despite only 2% of the cohort reporting

opioids as their current dug use at baseline. Cannabis, tobacco and alcohol were the main current drugs used at baseline among the majority of those deceased, and none of the deceased reported using opioids at baseline. This indicates a changing pattern of AOD use over time towards using mostly opioids among young people. Suicide was the second main cause of death in this cohort (12 of 50 deaths (24 %)), with the majority of these (67 %) being non-drug-related. Young people seeking treatment for co-occurring AOD use and psychiatric problems have increased risk of suicidal behaviour (Mertens et al., 2007; Nathan et al., 2020; Pompili et al., 2012; Schneider, 2009), and those with co-morbid psychiatric problems can be seen as highly impulsive and therefore exposed to a high risk of overdose (Ghodse et al., 1998; Oyefeso et al., 1999).

While the effectiveness of a treatment program cannot be evaluated based on mortality outcomes alone, this research suggests that self-harm and mortality rates are very high among treatment-attending young people. A major implication of this research is that residential treatment programs must incorporate and evaluate interventions to address co-morbidities including risk-taking behaviours and provide continuing aftercare that is accessed by a larger proportion of young people, as well as ensuring culturally appropriate care and support for Aboriginal young people (Nathan et al., 2020) to minimise relapse, self-harm and deaths. Further research on the interventions within TC approach to providing targeted treatment and preventing relapse, self-harm, suicide and AOD related deaths among young people is essential.

4.1. Strengths

This is the first long-term follow-up study (median follow-up of 8.9 years) on mortality and causes of death among AOD-using young people referred to residential treatment, using linked mortality data with minimal loss to follow-up. This study includes a non-attend group for comparison of mortality rates with treatment groups. Distinct from previous studies, this study contributes detailed analysis of causes of death including AOD-induced or AOD as a contributory cause of death.

4.2. Limitations

We could not determine if participants from the non-attend group had received treatment from other programs after their referral to PALM. Also, the mortality results for DSM-IV substance dependence and mental health characteristics may be biased due to data unavailability for these characteristics for 'non-attend' group for the 2001–2009 period. The cause of death data were available for only 50 of the 63 deaths of total deaths, which may lead to some bias in our estimates; however the effect of this bias is unknown.

5. Conclusion

This study found elevated mortality among treatment-seeking young people with AOD use, compared to the general population, with increased risks among females, the Aboriginal group, treatment group, and those having psychiatric comorbidity and experiences of trauma. Drug overdose, mainly opioids, and suicide were the main causes of death. Early screening for comorbidities, targeted treatment and continuing care or aftercare for these young people are vital to reduce AOD related harm and mortality. Our study demonstrates the importance of using linked datasets to understand populations such as young people seeking treatment for problematic drug use to examine their health, mental health and other long-term outcomes.

Role of the funding source

This research was supported by an Australian Research Council Linkage Projects funding grant (LP140100429) and the Ted Noffs Foundation. Sarita Bista was supported as a PhD student with a full scholarship at the UTS Sydney. The funding source had no role in study design, analysis and interpretation of data, preparation of manuscript, or any decision to submit the manuscript.

Contributors

Sarita Bista, Professor Hayen and A/Prof Nathan were involved in study design and first drafting of the manuscript. Sarita Bista and Professor Hayen were involved in statistical analysis. Dr Rawstorne, Kieren Palmer, Mark Ferry and Dr Williams were involved in reviewing of manuscript. Drs Nathan, Rawstorne, Williams, and Hayen were involved in obtaining funding. All authors were involved in agreement to submit.

Ethics approval and consent to participate

This publication has complete approval from the NSW Population & Health Services Research Ethics Committee (Cancer Institute NSW reference number 2015/10/616), the ACT Health Human Research Ethics Committee (ETH.11.15.216), and the Aboriginal Health & Medical Research Council (1144/15). The Ethics Committees granted a waiver of the usual requirement for the consent of the individual to the use of their health information in a research project, in line with the State Privacy Commissioner's Guidelines for Research and the Health Records and Information Privacy Act 2002 (NSW) and the Guidelines approved under Section 95 of the Privacy Act 1988.

Declaration of Competing Interest

Mark Ferry and Kieran Palmer are employees of the Ted Noffs Foundation, which operates the treatment programs which provided the client data for this study. Ted Noffs Foundation staff have not been directly involved in the analysis of the data. Mark Ferry and Kieran Palmer as authors have contributed to the write up of the findings by providing service provider insights. The Ted Noffs Foundation are also a signatory to an Australian Research Council Funding Grant (LP140100429) and associated contract. In this contract, Ted Noffs have stated their commitment to acting on the findings of the research undertaken in this study, both positive and negative, about their programs. No other authors have a conflict of interest to declare.

Acknowledgements

This research was supported by an Australian Research Council Linkage Projects funding grant (LP140100429) and the Ted Noffs Foundation. The author Sarita Bista was supported as a PhD student with a full scholarship at the University of Technology Sydney (UTS), Sydney, Australia.

We acknowledge the NSW Ministry of Health and ACT Health for the provision of data for this study. The Cause of Death Unit Record File (COD URF) is provided by the Australian Coordinating Registry for the COD URF on behalf of the NSW Registry of Births, Deaths and Marriages (RBDM), NSW Coroner and the National Coronial Information System (NCIS). The Centre for Health Record Linkage (CHeReL) is acknowledged for their role in data linkage. We also acknowledge the staff and residents of the Ted Noffs Foundation programs and the members of the Aboriginal Advisory Committee for their support and participation in the research. The Aboriginal Advisory Committee guided the study, with representatives of Aboriginal organisations, researchers, staff and young people who have completed the program. The full investigator team for the ARC Linkage Grant is acknowledged for their contributions to project governance and direction including CIs Nathan, Rawstorne, Hayen, Bryant, Baldry, Williams, Shanahan and Ferry.

References

Abdul-Rahman, A.-K., Card, T.R., Grainge, M.J., Fleming, K.M., 2018. All-cause and cause-specific mortality rates of patients treated for alcohol use disorders: a meta-analysis. Subst. Abus. 1–9.

Agosti, V., Levin, F.R., 2007. One-year posttreatment outcome of cannabis-dependent adolescents. Addict. Disord. Their Treat. 6 (2), 61–66.

Åhman, A., Jerkeman, A., Blomé, M.A., Björkman, P., Håkansson, A., 2018. Mortality and causes of death among people who inject amphetamine: a long-term follow-up cohort study from a needle exchange program in Sweden. Drug Alcohol Depend. 188, 274–280.

Albertella, L., Norberg, M.M., 2012. Mental health symptoms and their relationship to cannabis use in adolescents attending residential treatment. J. Psychoactive Drugs 44 (5), 381–389.

Arendt, M., Munk-Jørgensen, P., Sher, L., Jensen, S., 2011. Mortality among individuals with cannabis, cocaine, amphetamine, MDMA, and opioid use disorders: a nationwide follow-up study of Danish substance users in treatment. Drug Alcohol Depend. 114 (2-3), 134–139.

Australian Bureau of Statistics, 2016. 3303.0 - Causes of Death, Australia, 2016 [Internet], 2018 [cited 2019 May 16]. ABS Cat.No.3303.0. Available from:. Australian Bureau of Statistics, Canberra, Australia http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/3303.0~2016~Main%20Features~Drug%20Induced%20Deaths%20in%20Australia~6.

Australian Bureau of Statistics, 2017a. 3303.0 - Causes of Death, Australia, 2017 [Internet], 2018 [cited 2019 May 16]. ABS Cat. no. 3303.0. Available from:. Australian Bureau of Statistics, Canberra, Australia http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/3303.0~2017~Main%20Features~Deaths%20due%20to%20harmful%20alcohol%20consumption%20in%20Australia~4.

Australian Bureau of Statistics, 2017b. ABS.STat Datasets, 3302.0 – Deaths, Australia, 2017 [Internet]. ABS Cat. No. 3302.0. 2017 [cited 2019 April 27]. Available from: http://stat.data.abs.gov.au/Index.aspx?DatasetCode=DEATHS_AGESPECIFIC_REGISTRATIONYEAR.

Bartu, A., Freeman, N.C., Gawthorne, G.S., Codde, J.P., Holman, C.D.A.J., 2004. Mortality in a cohort of opiate and amphetamine users in Perth, Western Australia. Addiction 99 (1), 53–60.

Blood, L., Cornwall, A., 1994. Pretreatment variables that predict completion of an adolescent substance abuse treatment program. J. Nerv. Ment. Dis. 182 (1), 14–19.

Brown, S.A., Gleghorn, A., Schuckit, M.A., Myers, M.G., Mott, M.A., 1996. Conduct disorder among adolescent alcohol and drug abusers. J. Stud. Alcohol 57 (3), 314–324.

Brown, S.A., Tapert, S.F., Granholm, E., Delis, D.C., 2000. Neurocognitive functioning of adolescents: effects of protracted alcohol use. Alcohol. Clin. Exp. Res. 24 (2), 164–171.

Bukstein, O., Brent, O., Perper, J.A., Moritz, G., Baugher, M., Schweers, J., Roth, C., Balach, L., 1993. Risk factors for completed suicide among adolescents with a lifetime history of substance abuse: a case-control study. Acta Psychiatr. Scand. 88 (6), 403–408.

Crowley, T.J., Mikulich, S.K., MacDonald, M., Young, S.E., Zerbe, G.O., 1998. Substance-dependent, conduct-disordered adolescent males: severity of diagnosis predicts 2-year outcome. Drug Alcohol Depend. 49 (3), 225–237.

Darke, S., Mills, K.L., Ross, J., Teesson, M., 2011. Rates and correlates of mortality amongst heroin users: findings from the Australian Treatment Outcome Study (ATOS), 2001-2009. Drug Alcohol Depend. 115 (3), 190–195.

Dasinger, L.K., Shane, P.A., Martinovich, Z., 2004. Assessing the effectiveness of community-based substance abuse treatment for adolescents. J. Psychoactive Drugs 36 (1), 27–33.

Degenhardt, L., Roxburgh, A., Barker, B., 2005. Underlying causes of cocaine, amphetamine and opioid related deaths in Australia. J. Clin. Forensic Med. 12 (4), 187–195.

Degenhardt, L., Randall, D., Hall, W., Law, M., Butler, T., Burns, L., 2009. Mortality among clients of a state-wide opioid pharmacotherapy program over 20 years: risk factors and lives saved. Drug Alcohol Depend. 105 (1-2), 9–15.

Degenhardt, L., Bucello, C., Mathers, B., Briegleb, C., Ali, H., Hickman, M., McLaren, J., 2011. Mortality among regular or dependent users of heroin and other opioids: a systematic review and meta-analysis of cohort studies. Addiction 106 (1), 32–51.

Derogatis, L.R., 1993. BSI Brief Symptom Inventory Administration, Scoring and Procedures Manual. National Computer systems. Inc., Minneapolis, MN.

Dickson, J.M., Cruise, K., McCall, C.A., Taylor, P.J., 2019. A systematic review of the antecedents and prevalence of suicide, self-harm and suicide ideation in Australian Aboriginal and Torres Strait Islander youth. Int. J. Environ. Res. Public Health 16 (17), 3154.

Dixson, G., Woolfenden, S., Jayasinha, R., Rawstorne, P., Palmer, K., Nathan, S., 2018. Characteristics of Australian adolescent females in residential treatment who report using methamphetamines. Drug Alcohol Rev. 37, S384–S393.

Dudgeon, P., Cox, A., Walker, R., Calma, T., Milroy, J., Ring, I., Georgatos, G., Holland, C., Luxford, Y., 2016. Solutions That Work: What the Evidence of Our People Tell Us: Aboriginal and Torres Strait Islander Suicide Prevention Evaluation Report. School of Indigenous Studies, UWA, Perth, Western Australia.

Ericsson, E., Bradvik, L., Hakansson, A., 2014. Mortality, causes of death and risk factors for death among primary amphetamine users in the Swedish criminal justice system. Subst. Use Misuse 49 (3), 262–269.

Evans, E., 2015. Childhood Adversity and the Presence and Persistence of Substance Use Disorders Over the Life Course Among a Nationally Representative Sample of Adult Women. UCLA.

Evans, J.L., Tsui, J.I., Hahn, J.A., Davidson, P.J., Lum, P.J., Page, K., 2012. Mortality among young injection drug users in San Francisco: a 10-year follow-up of the UFO study. Am. J. Epidemiol. 175 (4), 302–308.

Fickenscher, A., Novins, D.K., Beals, J., 2006. A pilot study of motivation and treatment completion among American Indian adolescents in substance abuse treatment. Addict. Behav. 31 (8), 1402–1414.

Finney, J.W., Moos, R.H., Timko, C., 1999. The Course of Treated and Untreated Substance Use Disorders: Remission and Resolution, Relapse and Mortality, Addictions: a Comprehensive Guidebook. Apr 15:30-49.

Foster, M., Nathan, S., Ferry, M., 2010. The experience of drug-dependent adolescents in a therapeutic community. Drug Alcohol Rev. 29 (5), 531–539.

Garner, B.R., Godley, M.D., Funk, R.R., Dennis, M.L., Godley, S.H., 2007. The impact of continuing care adherence on environmental risks, substance use, and substance-related problems following adolescent residential treatment. Psychol. Addict. Behav. 21 (4), 488–497.

Ghodse, H., Oyefeso, A., Kilpatrick, B., 1998. Mortality of drug addicts in the United Kingdom 1967–1993. Int. J. Epidemiol. 27 (3), 473–478.

Gjersing, L., Bretteville-Jensen, A.L., 2014. Gender differences in mortality and risk factors in a 13-year cohort study of street-recruited injecting drug users. BMC Public Health 14 (1), 440.

Godley, M.D., Godley, S.H., Funk, R.R., Dennis, M.L., Loveland, D., 2001. Discharge status as a performance indicator: can it predict adolescent substance abuse treatment outcome? J. Child Adolesc. Subst. Abuse 11 (1), 91–109.

Gossop, M., Marsden, J., Stewart, D., Rolfe, A., 1999. Treatment retention and 1 year outcomes for residential programmes in England. Drug Alcohol Depend. 57 (2), 89–98.

Grella, C., 2006. The drug abuse treatment outcomes studies: outcomes with adolescent substance abusers. Adolescent substance abuse: Research and clinical advances 148–173.

Grella, C.E., Hser, Y.I., Joshi, V., Rounds-Bryant, J., 2001. Drug treatment outcomes for adolescents with comorbid mental and substance use disorders. J. Nerv. Ment. Dis. 189 (6), 384–392.

Hambley, J., Arbour, S., Sivagnanasundaram, L., 2010. Comparing outcomes for alcohol and drug abuse clients: a 6-month follow-up of clients who completed a residential treatment programme. J. Subst. Use 15 (3), 184–200.

Hawke, J.M., Jainchill, N., De Leon, G., 2000. Adolescent amphetamine users in treatment: client profiles and treatment outcomes. J. Psychoactive Drugs 32 (1), 95–105.

Hodgins, S., Larm, P., Molero-Samuleson, Y., Tengstrom, A., Larsson, A., 2009. Multiple adverse outcomes over 30 years following adolescent substance misuse treatment. Acta Psychiatr. Scand. 119 (6), 484–493.

Hser, Y.I., Grella, C.E., Hubbard, R.L., Hsieh, S.C., Fletcher, B.W., Brown, B.S., Anglin, M. D., 2001. An evaluation of drug treatments for adolescents in 4 US cities. Arch. Gen. Psychiatry 58 (7), 689–695.

Jainchill, N., 2000. Substance dependency treatment for adolescents: practice and research. Subst. Use Misuse 35 (12-14), 2031–2060.

Jainchill, N., Hawke, J., De Leon, G., Yagelka, J., 2000. Adolescents in therapeutic communities: one-year posttreatment outcomes. J. Psychoactive Drugs 32 (1), 81–94.

Jainchill, N., Hawke, J., Messina, M., 2005. Post-treatment outcomes among adjudicated adolescent males and females in modified therapeutic community treatment. Subst. Use Misuse 40 (7), 975–996.

Jason, L.A., Davis, M.I., Ferrari, J.R., 2007. The need for substance abuse after-care: longitudinal analysis of Oxford House. Addict. Behav. 32 (4), 803–818.

Larm, P., Hodgins, S., Larsson, A., Samuelson, Y.M., Tengstrom, A., 2008. Long-term outcomes of adolescents treated for substance misuse. Drug Alcohol Depend. 96 (1-2), 79–89.

Larm, P., Hodgins, S., Tengstrom, A., Larsson, A., 2010. Trajectories of resilience over 25 years of individuals who as adolescents consulted for substance misuse and a matched comparison group. Addiction 105 (7), 1216–1225.

Larm, P., C. Silva, T., Sheilagh, H., 2015. Adolescent substance misusers with and without delinquency: death, mental and physical disorders, and criminal convictions from age 21 to 45. J. Subst. Abuse Treat. 59.

Lindblad, R., Hu, L., Oden, N., Wakim, P., Rosa, C., VanVeldhuisen, P., 2016. Mortality rates among substance use disorder participants in clinical trials: pooled analysis of twenty-two clinical trials within the National Drug Abuse Treatment Clinical Trials Network. J. Subst. Abuse Treat. 70, 73–80.

Mathers, B.M., Degenhardt, L., Bucello, C., Lemon, J., Wiessing, L., Hickman, M., 2013. Mortality among people who inject drugs: a systematic review and meta-analysis. Bull. World Health Organ. 91, 102–123.

McCarthy, D.M., Tomlinson, K.L., Anderson, K.G., Marlatt, G.A., Brown, S.A., 2005. Relapse in alcohol- and drug-disordered adolescents with comorbid psychopathology: changes in psychiatric symptoms. Psychol. Addict. Behav. 19 (1), 28–34.

McCarty, C., E Ebel, B., Garrison, M., L DiGiuseppe, D., A Christakis, D., Rivara, F., 2004. Continuity of binge and harmful drinking from late adolescence to early adulthood. Pediatrics 114, 714–719.

Mertens, J.R., Flisher, A.J., Fleming, M.F., Weisner, C.M., 2007. Medical conditions of adolescents in alcohol and drug treatment: comparison with matched controls. J. Adolesc. Health 40 (2), 173–179.

Molero Samuelson, Y., Hodgins, S., Larsson, A., Larm, P., Tengström, A., 2010. Adolescent antisocial behavior as predictor of adverse outcomes to age 50: a follow-up study of 1,947 individuals. Crim. Justice Behav. 37 (2), 158–174.

Morral, A.R., McCaffrey, D.F., Ridgeway, G., 2004. Effectiveness of community-based treatment for substance-abusing adolescents: 12-month outcomes of youths entering

phoenix academy or alternative probation dispositions. Psychol. Addict. Behav. 18 (3), 257–268.
Muck, R., Zempolich, K.A., Titus, J.C., Fishman, M., Godley, M.D., Schwebel, R., 2001. An overview of the effectiveness of adolescent substance abuse treatment models. Youth Soc. 33 (2), 143–168.
Nambiar, D., Weir, A., Aspinall, E.J., Stoove, M., Hutchinson, S., Dietze, P., Waugh, L., Goldberg, D.J., 2015. Mortality and cause of death in a cohort of people who had ever injected drugs in Glasgow: 1982-2012. Drug Alcohol Depend. 147, 215–221.
Nathan, S., Bethmont, A., Rawstorne, P.R., Ferry, M., Hayen, A., 2016a. Trends in drug use among adolescents admitted to residential treatment in Australia. Med. J. Aust. 204 (4), 149–150.
Nathan, S., Rawstorne, P., Hayen, A., Bryant, J., Baldry, E., Ferry, M., Williams, M., Shanahan, M., Jayasinha, R., 2016b. Examining the pathways for young people with drug and alcohol dependence: a mixed-method design to examine the role of a treatment programme. BMJ Open 6 (5), e010824.
Nathan, S., Maru, K., Williams, M., Palmer, K., Rawstorne, P., 2020. Koori voices: self-harm, suicide attempts, arrests and substance use among Aboriginal and Torres Strait Islander adolescents following residential treatment. Health Justice 8 (1), 4.
Neumann, A., Ojong, T.N., Yanes, P.K., Tumiel-Berhalter, L., Daigler, G.E., Blondell, R.D., 2010. Differences between adolescents who complete and fail to complete residential substance abuse treatment. J. Addict. Dis. 29 (4), 427–435.
Nyhlen, A., Fridell, M., Hesse, M., Krantz, P., 2011. Causes of premature mortality in Swedish drug abusers: a prospective longitudinal study 1970-2006. J. Forensic Leg. Med. 18 (2), 66–72.
Oyefeso, A., Ghodse, H., Clancy, C., Corkery, J., Goldfinch, R., 1999. Drug abuse-related mortality: a study of teenage addicts over a 20-year period. Soc. Psychiatry Psychiatr. Epidemiol. 34 (8), 437–441.
Pompili, M., Serafini, G., Innamorati, M., Biondi, M., Siracusano, A., Di Giannantonio, M., Giupponi, G., Amore, M., Lester, D., Girardi, P., 2012. Substance abuse and suicide risk among adolescents. Eur. Arch. Psychiatry Clin. Neurosci. 262 (6), 469–485.
Schneider, B., 2009. Substance use disorders and risk for completed suicide. Arch. Suicide Res. 13 (4), 303–316.
Schulte, M.T., Hser, Y.-I., 2013. Substance use and associated health conditions throughout the lifespan. Public Health Rev. 35 (2), 3.
Singleton, J., Degenhardt, L., Hall, W., Zabransky, T., 2009. Mortality among amphetamine users: a systematic review of cohort studies. Drug Alcohol Depend. 105 (1-2), 1–8.
Stenbacka, M., Leifman, A., Romelsjo, A., 2010. Mortality and cause of death among 1705 illicit drug users: a 37 year follow up. Drug Alcohol Rev. 29 (1), 21–27.
Tripodi, S.J., 2009. A comprehensive review: methodological rigor of studies on residential treatment centers for substance-abusing adolescents. J. Evid. Soc. Work 6 (3), 288–299.
United Nations Office on Drugs and Crime, 2018. World Drug Report 2018. Sales No. E.18.XI.9; 2018 [Cited 2019 June 15]. Available from:. United Nations Publication https://www.unodc.org/wdr2018/prelaunch/WDR18_Booklet_1_EXSUM.pdf.
United Nations Office on Drugs and Crime, 2019. World Drug Report 2019. Sales No. E.19.XI.8; 2019 [Cited 2019 June 15]. Available from:. United Nations publication https://wdr.unodc.org/wdr2019/prelaunch/WDR19_Booklet_2_DRUG_DEMAND.pdf.
Vourakis, C., 2005. Admission variables as predictors of completion in an adolescent residential drug treatment program. J. Child Adolesc. Psychiatr. Nurs. 18 (4), 161–170.
Wei, C.C., Heckman, B.D., Gay, J., Weeks, J., 2011. Correlates of motivation to change in adolescents completing residential substance use treatment. J. Subst. Abuse Treat. 40 (3), 272–280.
Weinberg, N.Z., Rahdert, E., Colliver, J.D., Glantz, M.D., 1998. Adolescent substance abuse: a review of the past 10 years. J. Am. Acad. Child Adolesc. Psychiatry 37 (3), 252–261.
Wetherill, R., Tapert, S.F., 2013. Adolescent brain development, substance use, and psychotherapeutic change. Psychol. Addict. Behav. 27 (2), 393–402.
Whiteford, H.A., Degenhardt, L., Rehm, J., Baxter, A.J., Ferrari, A.J., Erskine, H.E., Charlson, F.J., Norman, R.E., Flaxman, A.D., Johns, N., 2013. Global burden of disease attributable to mental and substance use disorders: findings from the Global Burden of Disease Study 2010. Lancet 382 (9904), 1575–1586.
Winters, K.C., Stinchfield, R.D., Opland, E., Weller, C., Latimer, W.W., 2000. The effectiveness of the Minnesota Model approach in the treatment of adolescent drug abusers. Addiction 95 (4), 601–612.
Winters, K.C., Stinchfield, R., Latimer, W.W., Lee, S., 2007. Long-term outcome of substance-dependent youth following 12-step treatment. J. Subst. Abuse Treat. 33 (1), 61–69.
World Health Organization, 2018. Global Status Report on Alcohol and Health 2018, 2018. Licence: CC BY-NC-SA 3.0 IGO [Cited 2019 July 21]. Available from:. World Health Organization, Geneva https://apps.who.int/iris/bitstream/handle/10665/274603/9789241565639-eng.pdf.
Zabransky, T., Csemy, L., Grohmannova, K., Janikova, B., Brenza, J., 2011. Mortality of cohort of very young injecting drug users in Prague, 1996-2010. Cent. Eur. J. Public Health 19 (3), 152–157.