UTS UNIVERSITY OF TECHNOLOGY SYDNEY

Long-term Outcomes of a Residential Treatment Program for Adolescents with Problematic Drug and Alcohol Use: Evidence from a Longitudinal Modelling Approach Using Linked Data

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under the supervision of Prof Andrew Hayen/A/Prof Sally Nathan

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CERTIFICATE OF ORIGINAL AUTHORSHIP

I, *Sarita Bista*, declare that this thesis is submitted in fulfilment of the requirements for the award *of Doctor of Philosophy,* in the *School of Public Health*/*Faculty of Health* at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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Abstract

Among various alcohol and other drug (AOD) use treatment programs for adolescents, residential Therapeutic Community (TC) approach has received very little research attention, despite evidence showing that adolescents in residential program have severe AOD-use, psychiatric comorbidities, criminal involvement, and other related problems. Most extant research show improved AOD-use, health and related outcomes of residential program for adolescents in the short-term. There is very little rigorous research evaluating longer-term outcomes, with existing studies showing inconsistent findings. Therefore, important knowledge gaps exist. This study aims to address gaps by investigating post-program long-term patterns of mortality, AOD-use, and mental health outcomes and associated pre-treatment factors of adolescents referred to a residential TC program.

The sample included 3529 adolescents (13-18 years; median referral age=16.8 years; 73% male; 43% Aboriginal Australians; 51% justice-involved; 26% with severe/clinical psychological distress) referred to an Australian residential TC program called Program for Adolescents Life Management (PALM) using data-linkage following up to 16 years. I examined crude and standardised mortality rates, causes of deaths, post-PALM crude AOD- and MH-hospitalisation rates, and conducted growth mixture modelling (GMM) to identify distinct long-term AOD- and MH-hospitalisation trajectories, and multinomial logistic regressions to determine pre-treatment predictors of those trajectories.

Findings showed substantially higher mortality rate for the cohort, five times higher than the general population of same age-group. Two-thirds of deaths involved AOD, caused primarily by overdose (mainly opioids), suicide, and transport accidents. Both AOD- and MH-hospitalisation crude rates were substantially elevated for the cohort, one hospitalisation in five person-years. Mortality and hospitalisation rates were higher for females, Aboriginal Australians, older participants, those with greater psychological distress, and treatment-attending groups (vs non-attend group). Trajectory analyses showing one-third of participants having higher AOD- and MH-hospitalisations trajectories indicate no evidence of treatment effects for these subgroups including Aboriginal Australians, females, older participants, those with greater psychological distress, unstable living, cannabis and opioids as drug of concern (DoC). Two-thirds, mainly younger, non-Aboriginal, those with lower psychological distress, stable living, and justice-involved participants, demonstrated improved outcomes.

Finding of justice-involved participants showing improved outcomes prompt further research examining full extent of this relationship. Findings of poor outcomes for Aboriginal Australians, females, those with severe pre-treatment psychological problems, cannabis and opioids as DoC highlight the importance of early-screening and tailored, culturally safe, evidence-based integrated interventions, and longer and effective continuing care. Further research is needed to evaluate whether one AOD-program can address comorbidity and range of needs among diverse adolescents referred.

CHAPTER 1: Introduction to the study

Alcohol and other drug (AOD) use problems affect a substantial proportion of adolescents in Australia and globally (Degenhardt et al., 2016). During the past three decades, adolescents-specific correlates consequences, and treatment outcomes have been studied Existing literature has identified several risk and protective factors contributing to AOD use in young people, including contextual factors (e.g., availability of AOD, peer influence and deviant peer affiliation, school factors), demographic characteristics (age, gender, ethnicity and socio-economic status), family environment (e.g., supportive family, parent's or family member's AOD use, genetic factors), and personal characteristics (e.g., novelty and sensation seeking, oppositional behaviour, conduct disorder, and other mental health problems) (Anderson et al., 2007; Brown et al., 1994; Catalano et al., 1990; Degenhardt et al., 2016; Grella et al., 2010; Hawkins et al., 1992; Steinhausen et al., 2007). It is also becoming increasingly clear that AOD use problems during adolescence carries substantial risk (Brown & Ramo, 2006; Degenhardt et al., 2016), and the adolescent AOD use treatment field continues to make improvement by expanding evidence-based approaches (Winters et al., 2018). However, little is known about the adult outcomes of adolescents treated for AOD use problems. A critical but understudied perspective is the long-term effectiveness of AOD treatment for adolescents in reducing AOD use and related mental health and other outcomes as they transition from adolescence into young adulthood and adulthood. In this dissertation, I examine long-term outcomes of adolescents referred to a residential AOD treatment program in Australia.

In this chapter, I provide a background and rationale of the study including the prevalence of alcohol and illicit drug use[1], and mental illness among young people in Australia, concepts from developmental perspective and factors related to long-term adolescent AOD use, a statement of the problem, the purpose of the study and research questions, and the significance of the study.

[1] Definition of illicit drug use in Australia: Illicit use of drugs covers the use of a broad range of substances, including: (a) illegal drugs – drugs prohibited from manufacture, sale or possession in Australia, including cannabis, cocaine, heroin and amphetamine-type stimulants; (b) pharmaceuticals – drugs available from a pharmacy, over-the-counter or by prescription, which may be subject to non-medical use (when used for purposes, or in quantities, other than for the medical purposes for which they[1] were prescribed). Examples include opioid-based pain relief medications, opioid substitution therapies, benzodiazepines, steroids, and over-the-counter codeine (not available since 1 February 2018); (c) other psychoactive substances – legal or illegal, used in a potentially harmful way – for example, kava; synthetic cannabis and other synthetic drugs; inhalants such as petrol, paint, or glue (Source: Australian Institute of Health and Welfare. (2023b). *Illicit drug use*. AIHW. https://www.aihw.gov.au/reports/illicit-use-of-drugs/illicit-drug-use).

1.1 Background and rationale

Alcohol and illicit drug use among young people is a significant public health problem worldwide (Degenhardt et al., 2016). Adolescence is a key developmental period during which substantial changes occur within emotional, cognitive and neurobiological process. Adolescence is the time when the initiation of alcohol and other drug (AOD) use as well as the onset of mental health problems typically occur. The first co-occurrence of both AOD use and psychiatric conditions is common during adolescence (Esmaeelzadeh et al., 2018; Hawkins, 2009; National Institute on Drug Abuse, 2018; Wetherill & Tapert, 2013). Research suggests that the adolescent brain is more responsive to harmful effects of alcohol and illicit drug use, and early initiation of AOD use has been linked to long-term poorer decision making, behavioural and mental health problems (Brown et al., 2000; Weinberg et al., 1998; Wetherill & Tapert, 2013).

1.1.1 Prevalence of alcohol and illicit drug use among young people in Australia

Among the 15-24 year age group in Australia, alcohol and illicit drug use are the leading causes of the total burden of disease in males and the second and third leading causes for females (Australian Institute of Health and Welfare, 2019). The National Drug Strategy Household Survey (Australian Institute of Health and Welfare, 2017) reported that 18% of 14–19 years old consumed 5 or more drinks at least monthly, with 9.1% of males and 6.8% of females aged 12–17 exceeding the adult guidelines for single occasion risk, and 15.3% of people in their late teens and early 20s consuming 11 or more standard drinks at least monthly than people in other age groups. Similarly, the household survey found that 16% of young people aged 14–19 used illicit drugs (including pharmaceuticals) in the last 12 months. Proportional to the population, the 20–29-year-old age group was the most over-represented age group and made up the largest proportion (32%) of people who used illicit drug (Australian Institute of Health and Welfare, 2017). Most people in the survey first initiated using alcohol and drugs during their adolescence. The average age at which people aged 14–24 first tried alcohol was 16.1 years and the age of initiation into illicit drug use was 16.7 years among the people aged 14–29 (Australian Institute of Health and Welfare, 2017). Although the proportion of illicit drug use among the young people aged 14-19 years has significantly declined in 2019 compared to that in 2001 (38% in 2001 vs 22% in 2019), both males and females in this age-group reported increases in recent use of illicit drug (excluding pharmaceuticals) between 2016 and 2019 (from 15.4% males and 12.1% females in 2016 to 16% males and 14% females in 2016), with recent increases generally in cannabis, ecstasy and cocaine use among 14 years and over (Australian Institute of Health Welfare, 2020).

1.1.2 Prevalence of mental illness among young people in Australia

A first signs of mental illness commonly appear during adolescence. A mental illness can be defined as 'a clinically diagnosable disorder that significantly interferes with an individual's cognitive, emotional or social abilities' (Department of Health and Aged Care, 2022). A mental illness or mental disorder[2] covers a range of illnesses including anxiety disorders, affective disorders, psychotic disorders, and substance use disorders. The term "substance use disorders (SUD)"[3] involve the harmful use or dependence on alcohol or drugs, and encompasses both 'abuse' and 'dependence' (American Psychiatric Association & American Psychiatric, 1994; American Psychiatric Association & American Psychiatric, 2013). National study on mental health and wellbeing (NSMHWB) reports that the prevalence of mental disorders varies by age, with younger people having higher 12-month rates. Almost two in five young Australian (39.6%), with 46.6% of females and 31.2% of males aged 16-24 had a mental disorder in the past 12 month in 2021. The most prevalent mental disorder among young people aged 16-24 was anxiety disorders (31.5%), followed by Affective disorders (13.6%), with 41.3% of females this age having Anxiety disorders. People aged 16-24 years had the highest rates (9.1%) of 12-month substance use disorders (SUD) compared to other age groups (Australian Bureau of Statistics, 2021).

1.1.3 Health and social consequences of problematic AOD use of adolescents

Problematic AOD use among young people has a range of adverse psychological, physical, and social impacts, and is a growing concern in Australia and internationally (Australian Institute of Health and Welfare, 2017; Degenhardt et al., 2016). During the past three decades, studies have linked early problematic AOD use of young people with multiple adverse outcomes during their first decade of adult life, including continued problematic AOD use (Anderson et al., 2010; Evans, 2015; Larm et al., 2015; Larm et al., 2010; McCarthy et al., 2005; Winters et al., 2014), mental illnesses (Barkus & Murray, 2010; Brown et al., 2000; Evans et al., 2015; Köck et al., 2022; Loxley et al., 2004; Wetherill & Tapert, 2013), suicidal behaviour (Bukstein et al., 1993; Pompili et al., 2012), and premature death, primarily resulting from drug overdose and other substance-related unintentional injuries (e.g., motor vehicle accidents) (Bista et al., 2021; Darke et al., 2011; Degenhardt et al., 2013; Hodgins et al., 2009; Larm et al., 2015; Larm et al., 2008; Molero Samuelson et al., 2010; Roerecke & Rehm,

[2] The WHO WMH-CIDI 3.0 provides an assessment of mental disorders based on the definitions and criteria of two classification systems: the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV); and the WHO International Classification of Diseases, Tenth Revision (ICD-10) (Australian Bureau of Statistics. (2020-21). *National Study of Mental Health and Wellbeing*. ABS).

[3] See Appendix 2 for detail definition of SUD according to DSV-IV diagnostic manual.

2013). The well-established health consequences of AOD use disorder include heightened risk for morbidity, particularly human immunodeficiency virus (HIV) and hepatitis C virus (HCV) and drug-induced psychosis (Cumming et al., 2020; Degenhardt et al., 2016; Mertens et al., 2007; Schulte & Hser, 2013). Health conditions related to excessive alcohol use or drug dependence include cirrhosis, heart disease, pancreatitis, diabetes mellitus, certain cancers, major depression, and several other chronic and acute diseases and conditions (McLellan et al., 2000; Parry et al., 2011; Rehm et al., 2010). Problematic AOD use also increases the risk of subsequent recidivism (Cumming et al., 2020).

Harmful alcohol and illicit drug use among young people has extensive social and economic costs for the community and the economy including the cost of the resources used to address health and hospital systems from injuries and trauma, chronic disease and disability, criminal consequences of problematic alcohol and drug use as well as the loss of potential productivity, death, and lost workplace productivity, and mental health impacts (Australian Institute of Health and Welfare, 2023a; Baker et al., 2021; Stephens et al., 2019). The cost of mental health disorders and suicides among Australians is over $33.6 billion each year and the cost of substance use disorders (SUD) is almost $10 billion each year (Mindgardens Neuroscience Network, 2019). The estimated costs are as high as $200–220 billion each year when the full impact of productivity loss, reduced life expectancy, and the social and emotional costs of mental illness and suicide are considered (Baker et al., 2021; Productivity Commission 2020).

1.1.4 AOD Treatment for adolescents and treatment outcomes

During the last two decades, increased concern about young people's AOD use has led to a growing number of different types of AOD treatment programs with different treatment intensities (e.g., brief intervention, outpatient, inpatient, residential, and medically managed inpatient) for adolescents (Joe et al., 2014; Williams & Chang, 2000). These treatment programs use different approaches such as 12-step, therapeutic community (TC), family-based interventions, behavioural therapy, cognitive behaviour therapy (CBT), motivational-based therapy, etc. However, there remains considerable debate on the most appropriate program and approaches to the prevention and treatment of harmful AOD use among adolescents. Most existing literature on treatment programs and their effectiveness are concentrated on adults with alcohol and drug dependence, with a lack of research focusing on adolescent drug treatment effectiveness (Brown et al., 2001; Hser et al., 2001). Young people with problematic AOD use are different from adults in many ways that young people, particularly 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; Winters et al., 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).

Although the majority of the existing studies on adolescents conducted during the last three decades made significant advances in development and evaluation of several evidence-based treatment approaches, the focus was mainly on the approaches for outpatient programs (Waldron & Turner, 2008). Residential program with 12-step and TCs for adolescents received very little empirical attention (Winters et al., 2018) despite some national studies in the USA during the 1990s indicating that residential drug treatment are more effective for the adolescent population than outpatient treatment (Jainchill et al., 1995; Jainchill et al., 1997) and adolescents referred to residential program generally having greater severity of AOD use and mental health problems, criminal histories, and other problems (Morral et al., 2004; Williams & Chang, 2000). Of the studies conducted to date on the effectiveness of residential treatment for adolescent AOD use, the majority have examined short-term treatment effects at 3 or 6 or 12 months post-treatment (Agosti & Levin, 2007; Albertella & 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). These outcome studies have shown that residential treatment programs have positive impacts on substance use, health and related outcomes for adolescents in the short term.

Only a handful of studies have evaluated the long-term outcomes of residential AOD treatment for adolescents (e.g., Brown et al., 2011; Edelen et al., 2010; Hawke et al., 2003; Jainchill et al., 2005). These studies showed positive effects on reducing substance abuse and psychological functioning in the first 12 months post-treatment but had mixed results in the longer term. For example, Brown, Ramo & Anderson (2011) reported a reduction in alcohol and other drug use up to 4 years of post-treatment, whereas another studies (Edelen et al., 2010; Hawke et al., 2003; Jainchill et al., 2005) found no long-term effects of treatment on substance abuse and other outcomes. Overall, there is a lack of evidence to determine whether residential treatment is effective for adolescent with substance use disorder (SUD) in the long term. There is also issues with the quality and methodological rigour of existing studies to determine the effectiveness of the residential treatment for the adolescents, such as loss to follow up, no control groups, pre/post survey design (Tripodi, 2009; Williams & Chang, 2000). In sum, there is a dearth of long-term residential outcome studies using large samples, strong comparison groups, and appropriate and robust study designs. Lack of consistent findings among the existing literature on long-term studies underscore a need for more

long-term and methodologically strong studies to evaluate long-term effectiveness of residential TC treatment for adolescents.

1.1.5 Developmental perspective and risk factors of long-term AOD use among young people

AOD use increases with age as part of developmental changes in adolescence. Although, adolescence is a stage of experimental consumption of alcohol, tobacco and other drugs such as cannabis, which is normative for some in this age range, for others, this pattern may lead to problematic AOD use, dependence or substance use disorder (SUD), which may persist into adulthood (Schulte et al., 2009; Wittchen et al., 2008). However, there is a limited empirical knowledge on longitudinal developmental trajectories of problematic AOD use including psychosocial correlates of young people, although the theoretical models[4] such as life course (Hser et al., 2007) and developmental psychopathology (Chassin et al., 2013; Cicchetti & Rogosch, 2002). emerged few decades ago providing justification for continuation of AOD use from adolescence to young adulthood and adulthood.

Limited longitudinal studies show that AOD use increases from early to late adolescence and reach their peak prevalence during emerging adulthood (usually defined as the period from age 18 to age 25) (Anderson et al., 2010; Chen & Kandel, 1995; Chen & Jacobson, 2012; Eschmann et al., 2011; Johnston, 2010; Jordan & Andersen, 2017; Park et al., 2018; Stone et al., 2012). This body of research examining long-term developmental patterns of AOD use has identified different patterns of AOD-related outcomes for those who received AOD treatment as adolescents. Patterns of AOD use over developmental period are heterogeneous, with many young people reduce or stop using AOD after treatment (e.g., abstinent or reduction in use) which are largely maintained, but for others, AOD use becomes a chronic and recurring condition, often spanning to their young adulthood and beyond (Anderson et al., 2010; Chung et al., 2004; Chung et al., 2008). For example, Anderson et al. (2010) described six distinct patterns of AOD use during the decade following adolescent for AOD use after inpatient treatment: (1) *Abstainers/Infrequent Users,* (2) *Late Adolescent Resurgence,* (3) *Emerging Adulthood Resurgence,* (4) *Frequent Drinkers,* (5) *Frequent Drinkers/Drug Dependent,* and (6) *Chronic.* The authors found that long-term AOD use appears to negatively influence educational attainment, occupational and socioeconomic status, and marriage/cohabitation relationships during young adulthood. This approach of investigation not only identifies heterogenous subgroups in the sample, but also the high-risk groups. These findings highlight the need to explore AOD use and identify subgroups more explicitly by using a developmental perspective across a longer period (i.e.,

[4] Description of these theoretical models is beyond the scope of this research.

from early adolescence, to young adulthood and adulthood) to understand the developmental impact and later outcomes.

Evidence shows that several individual and environmental factors influence the development and continuation of AOD use from adolescence to young adulthood, which have been summarised in major reviews. These factors include life stress, genetic and individual personality (e.g., sexual orientation, delinquency, and suicidal behaviour), family environment (parental AOD use, family violence), peer influences, academic factors, and other environmental factors (Anderson et al., 2007; Armstrong & Costello, 2002; Brown et al., 2000; Chen & Jacobson, 2012; Chung & Maisto, 2006; Couwenbergh et al., 2006; Esposito-Smythers & Spirito, 2004; Hulvershorn et al., 2015; Marshal et al., 2008; Nolen-Hoeksema, 2004; Weinberg et al., 1998). Furthermore, demographic factors such as age, gender, race/ethnicity have been inconsistently reported in a small number of long-term studies. Some studies showed that males are more frequently diagnosed with alcohol use disorders, but these gender effects are stronger in younger adolescents and fade out with increasing age, particularly there are no gender differences in the rates of tobacco dependence and cannabis use disorders (Nolen-Hoeksema, 2004; Palmer et al., 2009; Schulte et al., 2009) and across the AOD use trajectory classes (Anderson et al., 2010). However, other studies report gender differences in developmental patterns of AOD use, with females showing higher levels of AOD use in early adolescence and males exhibiting greater changes over time and higher levels of use in mid-adolescence and early adulthood (Chen & Jacobson, 2012), and significantly less females showing poorer cannabis use trajectory (Campbell et al., 2016).

Only a handful of longitudinal studies have provided evidence for racial/ethnic differences in AOD use trajectories, however the findings are inconsistent. Some studies from the US report that African Americans have lower initial levels and lower increasing rates of AOD use than their Caucasian counterparts (Flory et al., 2006), but others show that Caucasian adolescents have higher rates and levels of AOD use from mid-adolescence through the early 30s, and African Americans have higher final levels of smoking and marijuana use than the other racial/ethnic groups in the long-term (Chen & Jacobson, 2012). However, some evidence shows no ethnic differences across the AOD use trajectories (Anderson et al., 2010; Campbell et al., 2016). There is none in Australian context to investigate the longitudinal trajectory patterns of AOD of adolescents identified as Aboriginal and/or Torres Strait Islander comparing with non-Indigenous ethnicity.

Evidence show that problematic AOD use is a primary risk factor for adolescents' involvement with the criminal justice system (Australian Institute of Health and Welfare, 2018; Bennett et al., 2008). But very limited studies have investigated the long-term AOD use of adolescents with criminal justice

system. Involvement in the criminal justice system can exacerbate pre-existing adversities including problems with AODs, and potentially returning to the AOD use and criminal behaviour (Whitten et al., 2022). A US study on women treated for AOD use disorder suggests that involvement with the criminal justice system appears to be a key factor that explains a return to AOD use and other poor outcomes over time (Evans et al., 2013).

Another important factor that influences the long-term AOD use among young people is the comorbid mental health problems (Chassin et al., 2004; Chassin et al., 2013). This complex group of AOD using young people is often characterized by co-occurring psychiatric disorders. Evidence suggests that, compared with adolescents with AOD use problems alone, adolescents with AOD use and comorbid psychiatric disorders are more likely to be at higher risk of harm including carrying substantial and intersecting risks into adulthood including greater risk of relapse, and continued AOD use or dependence (Bender et al., 2006; Brewer et al., 2017; Deas, 2006; Hawkins, 2009), hospitalisations, suicidal behaviour, and death (Bista et al., 2021; Hodgins et al., 2009; Larm et al., 2008). Additionally, adolescents with comorbid AOD use and psychiatric diagnoses are less likely to respond to treatment (Ramchand et al., 2014; Shane et al., 2003). Some other studies suggest that having a psychiatric disorder in adolescence is a potent risk factor for having a psychiatric disorder in adulthood (Castagnini et al., 2016; Copeland et al., 2013). Although there is no clear evidence on which one causes other first between AOD use disorders and comorbid mental illnesses, National Institute on Drug Abuse (NIDA) suggests that there are three main pathways that contribute to the comorbidity between AOD use disorders and mental illnesses (National Institute on Drug Abuse, 2018; Santucci, 2012). First, common risk factors can contribute to both mental illness and AOD use and addiction. The common risk factors are individual factors such as genetic and epigenetic vulnerability, and environmental factors such as chronic stress, trauma, and adverse childhood experiences, among others. Second, mental illnesses can contribute to AOD use and addiction. Third, AOD use and addiction can contribute to the development of mental illness (National Institute on Drug Abuse, 2018).

Since everyone has different sets and degrees of risk and protective factors for involvement in AOD use, a greater understanding of these factors at treatment intake and their role in impacting the treatment outcomes during their transition into young adulthood has significant implications for designing customised interventions and continuing care for young people. However, little is known regarding the empirical evidence on long-term developmental patterns of AOD use as well as mental illness patterns and the factors associated with these outcomes of young people with problematic AOD use and comorbid mental illness who received AOD treatment during their adolescence.

1.1.6 Limitations in the current treatment outcome research

There is a gap in the literature in AOD use treatment outcome research, particularly the outcomes of residential treatment with a Therapeutic Community (TC) approach for adolescents. Despite there is a growing body of empirical research on outcomes of several other AOD treatment programs, residential TC approach has received a very little attention (Winters et al., 2018) to date, despite adolescents in residential treatment having been found to have complex histories including trauma, comorbid psychiatric conditions, history of arrests, experience of sexual and physical abuse, and family histories of problematic AOD use (Dixson et al., 2018; Jainchill et al., 2005; Nathan, Bethmont, et al., 2016; Nathan et al., 2020; Neumann et al., 2010; Vourakis, 2005).

Within this small body of literature on residential treatment outcomes, most of the existing empirical research has evaluated short-term (up to one year or less) outcomes of AOD use, health, and psychological functioning of adolescents treated in residential program (Agosti & Levin, 2007; Albertella & 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). There is a gap in the knowledge on the long-term treatment outcomes. Additionally, the existing long-term studies have poor methodological rigours due to small samples, lack of strong control group, and appropriate study design and analytical approaches, and self-reported data (Tripodi, 2009). Self-reported follow-up data are prone to have greater risks of attrition as well as risks of biasness due to recollection of past events, and involves greater operational and time costs (Caruana et al., 2015; Gustavson et al., 2012).

Additionally, despite past research suggesting that mental illnesses can contribute to AOD use and addiction, and AOD use and addiction can contribute to the development of mental illness, little is known regarding the empirical evidence on the long-term developmental patterns of post-treatment AOD use as well as mental health outcomes. Also, there is very limited knowledge on the pre-treatment factors associated with these patterns of outcomes of young people with problematic AOD use and comorbid mental illness. To our knowledge, no research has been conducted to date to investigate heterogenous subgroups and their distinct trajectory patterns of post-treatment AOD use and mental health outcomes of adolescents referred to residential programs. More importantly, given a large proportion of adolescents referred to residential programs have comorbid mental health problems, along with other pre-treatment adversities such as unstable living, involvement with criminal justice system, there is a shortage of evidence on whether these pre-treatment factors, in addition to their demographic characteristics, impact differently on distinct patterns of long-term outcomes. Although only a handful of studies have examined differences of demographic variables

such as age, gender, ethnicity across the outcomes or impact of these variables on the long-term outcomes, findings are less consistent, highlighting a need for more research examining a range of demographic and pre-treatment variables to determine the differences of outcomes across the groups of these variables.

Therefore, these gaps underscore a need for more prospective studies with longer follow-ups up to 10 years or more covering the period of transition from adolescence to young adulthood and adulthood, using large samples, strong comparison groups, and appropriate and robust study designs with no attrition to provide evidence on distinct developmental patterns of long-term residential treatment outcomes of young people and to identify the high-risk subgroups at earlier stage of treatment.

1.2 Current study

1.2.1 Purpose of this study

In light of these significant gaps and limitations of the extant literature on residential treatment outcomes of adolescents as mentioned in the previous section, the purpose of this study was to address those key gaps and to evaluate the effectiveness of a residential AOD program for adolescents by providing evidence on the longer-term patterns of treatment outcomes and how pre-treatment and treatment factors were associated with those trajectory patterns. For this dissertation, I used data from a larger sample (N=3529) of AOD treatment-seeking adolescents (13-18 years) referred to TED Noffs Program for Adolescent Life Management (PALM) for their problematic AOD use and related problems who were followed up to 16 years. PALM is a residential program using modified Therapeutic Community (TC) approach, operating in New South Wales (NSW) and Australian Capital Territory (ACT) in Australia, designed to address AOD use, comorbid mental problems, and other related issues in a holistic manner. PALM takes a harm minimization approach as opposed to an abstinence approach, and aims to equip adolescents with skills to manage their lives effectively post treatment (Foster et al., 2010). The treatment setting and approaches of PALM program are described in Section 3.4 in Chapter 3 (Methods).

To understand the characteristics of the participants or subgroups who showed better outcomes and the subgroups with poorer outcomes (high-risk group) in the long-term, this study examined a range of demographic variables including age at referral, sex at birth, Indigenous status, pre-treatment variables including severity of comorbid psychological distress, involvement with justice system, severity of AOD use, principal drug of concern (DoC) at referral, number of places lived during last six months. Using these variables, this study provided evidence of whether the outcomes were different

across the groups or categories of these variable, and which variables were associated with the long-term trajectories of the outcomes.

The treatment program variable was measured by the length (days) In the PALM program before the follow-up began, and categorised in three groups as: (a) 'days>30', who stayed in program over 30 days and up to three months (b) 'days≤30', who stayed four to 30 days, and (c) 'non-attend', who were referred and assessed, but did not attend the program or attended only up to 3 days (0-3 days), which was the comparison group for the analysis. Although detailed and consistent data were not available on reasons for not-attending the program, the recorded reasons often included: being refused bail, assessed as not being eligible, or loss of interest (Dixson et al., 2018; Nathan et al., 2020).

In evaluating the effectiveness of the residential TC (PALM) program, this study examined three different outcomes: mortality, AOD related hospitalisations (AOD-hospitalisations), and mental health related hospitalisations (MH-hospitalisations) of those who were referred to residential TC when they were adolescents, using longitudinal linked mortality and hospital admission administrative data following up to 16 years after PALM program. There were three overarching aims of this study:

1. Estimate mortality rates and determine causes of deaths in adolescence, early adulthood or adulthood among adolescents referred to AOD residential treatment
2. Determine overall AOD-hospitalisation rate for the cohort, identify distinct subgroups of adolescents in the sample with distinct developmental trajectory patterns of AOD-hospitalisations from adolescence through to adulthood, and determine predictors of each trajectory class, and
3. Determine overall MH-hospitalisation rate for the cohort, identify distinct subgroups in the sample with distinct trajectory patterns of MH-hospitalisations from adolescence into adulthood, and determine predictors of each trajectory class.

1.2.2 Research questions

Each aim of this dissertation was addressed by conducting a separate study. Therefore, there were three separate studies presented in Chapter 4 – Chapter 6 of this dissertation. Each study was guided by the following research questions to achieve the respective aims.

Aim 1: To address Aim 1, I formulated the following research questions:

(a) What are the mortality rates among residential treatment-seeking young people for problematic AOD use, comparing mortality rates with the general population?

(b) What are the mortality patterns by demographic, pre-treatment AOD-use and mental health characteristics?

(c) Are the mortality rates among the treatment-attend groups lower than the mortality rates among non-attend group?

(d) What are the patterns of AOD- and non-AOD-related causes of death?

Aim 2 and Aim 3: To achieve Aim 2 and Aim 3, this study answered the following research questions:

(a) What are the AOD-hospitalisation (Aim 2) and MH-hospitalisation (Aim 3) rates for the cohort?

(b) Are the AOD-hospitalisation (Aim 2) and MH-hospitalisation (Aim 3) rates different across individual and contextual variables such as sexes, different referral age-groups, groups by Indigenous status, pre-treatment mental health scores, and pre-treatment substance dependence scores?

(c) Are the AOD-hospitalisation (Aim 2) and MH-hospitalisation (Aim 3) lower for the treatment-attend groups, compared to non-attend group?

(d) Are there different subgroups of participants who exhibit distinct AOD-hospitalisation (Aim 2) and MH-hospitalisation (Aim 3) patterns (trajectories) but participants in each subgroup share similar AOD-hospitalisation (Aim 2) and MH-hospitalisation (Aim 3) patterns over time from adolescence through to adulthood?

(e) Which pre-treatment individual and contextual variables predict those identified AOD-hospitalisation (Aim 2) and MH-hospitalisation (Aim 3) trajectories and differentiate the trajectory patterns? In other words, who are likely to be classified in the higher level of AOD-hospitalisation trajectory classes and who are likely to be in lower level of hospitalisation trajectories?

1.3 Significance of the current study

This research significantly contributes to the existing limited evidence base by providing evidence of long-term effects of residential TC treatment program for adolescents on outcomes such as mortality, AOD-hospitalisations and mental health related hospitalisations, which have not been investigated previously. Because of the strong methodological rigour of this research due to data linkage of outcomes with administrative data for a larger sample which allowed follow-ups for a

longer period of time with no loss-to-follow-up and minimised cost, and inclusion of no treatment group as a comparison group , and examination of several baseline variables, the significance of the findings of this research can be greater, particularly the findings on outcomes of those who have greater severity of comorbid mental health problems and other adversities, females, Aboriginal participants, and those who were involved with the justice system. This study provides evidence of heterogeneity in the treatment responses of the young people over time by identifying different subgroups with distinct trajectories of AOD- as well as MH-hospitalisation outcomes. The use of more diverse sample in this research help understand potential age, gender and ethnicity differences in AOD use and mental health outcomes during early to late adolescence. These findings provide a greater understanding of the characteristics of different subgroups including the high-risk group, and how these subgroups have responded to the treatment in the long-term. This informs PALM and other treatment programs about who needs unique treatment, service redesign, and targeted interventions and effective continuing care. These findings will be vital not only for the PALM program, but also for the broader drug and alcohol field and across the service delivery sector including government to introduce new programs, policies and innovative practices that may be more responsive, effective, and culturally safe in addressing a range of issues of high-risk adolescents.

1.4 Overview of the dissertation

In this chapter, I included a brief examination of the current literature, and literature gaps and limitations for the background and rationale of this study, purpose and aims of the current study, research questions, and the significance of the study.

In Chapter 2, I present literature in greater depth, focusing mainly on the current treatment programs, treatment outcome research, and emerging longitudinal studies examining developmental patterns of AOD use from early adolescence through adulthood.

In Chapter 3, I describe the methods used for this research. Since the specific methods used for each study conducted to address Aim 1- Aim3 are presented in the next corresponding chapters (Chapter 4- Chapter 6), in this chapter, I present overall study design and ethics approval, participants, data linkage process, treatment setting, statistical analysis and anticipated outcomes.

Chapter 4 contains a study to address Aim 1 on the mortality outcome among adolescents referred to PALM program using the mortality linked data following up to 16 years. This chapter presents the background, methods used, results, and discussion and conclusion in an article format, which was published in Drugs and Alcohol Dependence in 2021. In this chapter, I calculated mortality rates

(crude mortality rates (CMR) and the standardised mortality rates (SMR)) for the cohort, and across the demographic and pre-treatment variables. I also examined the causes of death in three categories: AOD as underlying cause, AOD as secondary cause, and non-AOD cause.

Chapter 5 (Aim 2) is a study on AOD-hospitalisation outcomes of PALM participants using hospital admission linked data following up to 16 years post-PALM. This chapter presents this study in an article format (currently under review by Drug and Alcohol Dependence) including background, methods, results, and discussion and conclusion. The analyses in this study were in three stages. First, I calculated the AOD-hospitalisation crude rates and adjusted rates (using negative binomial regression). In the second stage, I thoroughly analysed heterogeneity in the outcome and identified distinct AOD-hospitalisation trajectory patterns of the participants following 10 years post-PALM using growth mixture modelling (GMM), and in the third stage, I thoroughly examined the predictors (demographic, pre-treatment and treatment variables) of those trajectories using multinomial logistic regression.

Chapter 6 addresses Aim 6 by conducting a thorough analysis of mental health related hospitalisation (MH-hospitalisations) outcome using linked hospital admission data following up to 16 years post-PALM. This chapter presents background, methods, results and discussion and conclusion. The analyses for this study were in three stages. In the first stage, I calculated the MH-hospitalisation crude rates and adjusted rates (using negative binomial regression). Then, I examined the heterogeneity in the mental health outcomes of the participants, and identified distinct MH-hospitalisations using growth mixture modelling (GMM), and in final stage, I thoroughly examined the demographic, pre-treatment and treatment variables associated with those trajectories using multinomial logistic regression.

In the Discussion (Chapter 7), I first summarise the main results of each study on Aim 1-Aim 3 (Chapters 4-6) in brief, and then I synthesise the key finding from all three studies. In this chapter, I also discussed the strengths and limitations of this research, implication of this research for the service providers and for the future research, and conclusion of the research.

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CHAPTER 2: Literature Review

In this chapter, I present a literature review of conceptual and empirical literature on treatment modalities, approaches, treatment effectiveness, post-treatment outcomes for adolescents with problematic AOD, and emerging longitudinal studies examining developmental patterns of AOD use from early adolescence through adulthood. The focus of literature will be on effectiveness of AOD treatment programs, mainly residential program, on the outcomes of referred adolescents in both short-term and long-term.

First, to facilitate a review of literature, I present the definitions of some terminologies from the literature of this area of research, and therefore these terminologies will be frequently used in the review in this chapter. I will then describe the theories that will be used to understand the research literature.

Definitions of terminologies:

Substance Use Disorders (SUD):

Various terms are used in the literature to refer to SUDs. These terms include use, abuse, and dependence. Substance use is a term used to describe a person who uses substances. The term substance use problem suggests that a person is reporting problems associated with substance use. These problems may be related to abuse or dependence. Substance abuse is the term used to refer to someone who meets DSM-IV criteria for the abuse of alcohol or another drug. Substance abuse, according to the DSM, is a pattern of substance use that leads to clinically significant problems. Symptoms of abuse include failing to meet obligations at work, school, or home; using in dangerous situations; experiencing repeated legal problems; or experiencing social or relationship problems. A person meets criteria for substance abuse if he or she has one or more of these symptoms.

Substance dependence is the term used to describe someone who has more serious problems with substance use. A person with substance dependence may have symptoms such as tolerance; withdrawal; using the substance more or for a longer time than intended; being unable to cut down or control substance use; spending a lot of time getting, using, or feeling the effects of a substance; giving up or reducing social, job, or recreation activities; or continuing to use despite knowing that the substance use is causing or adding to a physical or psychological problem. A person who has three or more of these symptoms would meet the criteria for substance dependence. If a person meets criteria for substance abuse and dependence, they would be diagnosed with dependence because it is the more serious disorder. In general, the term SUD is used to describe meeting criteria for abuse or dependence for any substance including alcohol.

Definition of these terms according to DSM-IV criteria are provided in Supplementary Appendix 2.

Mental Health Disorders (MHD):

Like SUDs, there are multiple terms used to refer to MHDs. MHDs can include anxiety disorders; mood disorders like depression, dysthymia, and bipolar disorder; attention-deficit hyperactivity disorder (ADHD); conduct disorder; oppositional defiant disorder; and post-traumatic stress disorder. This literature review and the study will focus on the MHDs most often diagnosed in adolescents: depression, anxiety, ADHD, conduct disorder, and traumatic stress. As mentioned in Chapter 1, the term disorder is typically used to refer to a person who has met DSM-IV criteria for a mental health disorder. Because of the nature of the measures used in the Global Appraisal of Individual Needs (GAIN)[5] for mental health disorders, when the study is discussed, the term mental health problem will be used, instead of MHD. In contrast, in my descriptions of the literature reviewed, I will use the terms the researchers used.

Co-occurring Disorders:

When a person meets criteria for both a SUD and a MHD the person is typically described as having a co-occurring disorder. However, multiple terms have been used to describe people who have both SUDs and MHDs. These terms include dual diagnosis, co-morbid, co-occurring, and co-existing. For the purposes of this dissertation, the term that is most commonly used in the literature at this time, co-morbid, will be used to describe people with both a MHD and a SUD.

2.2 Treatment programs for adolescents

There are different treatment programs available for adolescents with substance use disorder and they vary greatly in terms of treatment intensity and setting, treatment duration, and comprehensiveness (Williams & Chang, 2000).

2.2.1 Treatment intensity and treatment modalities

Broadly, five types of treatment programs exist along a continuum of intensities of care. The treatment programs are provided in different settings such as outpatient, day treatment, residential

[5] The Global Appraisal of Individual Needs (GAIN) is an evidence-based and comprehensive biopsychosocial assessment tool used with both adolescents and adults and in outpatient, intensive outpatient, partial hospitalization, methadone, short-term residential, long-term residential, therapeutic community, and correctional programs. The GAIN has eight core sections (Background, Substance Use, Physical Health, Risk Behaviors and Disease Prevention, Mental and Emotional Health, Environment and Living Situation, Legal, and Vocational). Each section contains questions on the recency of problems, breadth of symptoms, and recent prevalence as well as lifetime service utilization, recency of utilization, and frequency of recent utilization (Dennis, M. L., Titus, J. C., White, M. K., Unsicker, J. I., & Hodgkins, D. (2003). Global appraisal of individual needs: Administration guide for the GAIN and related measures. *Bloomington, IL: Chestnut Health Systems*).

and inpatient settings. The five main treatment programs are early and brief intervention services, outpatient treatment, intensive outpatient, inpatient/residential treatment, and medically managed intensive inpatient treatment both Winters (Winters et al., 2011; Winters et al., 2014). The patient's referral to one of these programs and placement is determined by assessment criteria, particularly the degree and nature of the adolescent's drug use and related problems, and the environment and quality of the support that the adolescent has external to the program (Winters et al., 2014). In the USA, the treatment programs use the assessment criteria developed by the American Society of Addiction Medicine (ASAM), which assess the patients in six areas of substance use and related factors such as severity of intoxication and withdrawal, current and past medical condition, mental health condition, readiness to change substance use behaviour, risk of relapse and potential for continued substance use, and environment for recovery including family, friends and living condition (Winters et al., 2014).

The hierarchical level of care and the treatment duration of the five main treatment programs (Winters et al., 2014) are briefly provided below. Winters et al. (2014) provide a review of current treatment programs and is used as a basis for the descriptions of following five treatment programs.

Early and brief intervention services

These are brief intervention or educational services particularly for the adolescents who have positive history of use but no or low current use.

Outpatient treatment

Adolescents who have less severe or low to moderate substance use problems and are able to function in a non-structured outpatient setting are often referred to outpatient treatment settings. This treatment program is also commonly used as a next step for continuing care after a more intensive residential treatment program. The outpatient treatment involves attending sessions for 6 hours per week or less for planned treatment duration. Treatment options such as individual, group and family therapy are available. The majority of the behavioural therapies and some of the family-based therapies are delivered in outpatient setting.

Intensive Outpatient

In this outpatient setting, adolescents receive comprehensive treatment by attending up to 20 hours per week. The program length varies from 2 months to one year as required.

Residential/inpatient treatment

Adolescents with severe substance use problems including comorbid complex mental health issues, family or other health problems resulting from substance use disorders are often referred to residential/inpatient treatment programs. This program is provided in residential/inpatient setting with treatment length lasting from one month to one year and includes a range of treatments for psychosocial and behavioural change and life skills. There are two main treatment approaches, the therapeutic community (TC) and Minnesota model delivered in the residential/inpatient treatment setting.

Medically managed intensive inpatient treatment

This is the highest level of treatment where adolescents with severe substance use and other related problems requiring a 24-hour primary medical care and monitoring. The program length varies depending on the patient's condition.

2.2.2 Treatment Approaches

There are a wide range of treatment approaches available for adolescent substance use and related problems, and these approaches are implemented within the five hierarchical treatment and care levels provided above. Most of the approaches incorporate a broad range of therapeutic models within their treatment services. Four main (Sussman et al., 2008; Winters et al., 2011; Winters et al., 2009; Winters et al., 2007; Winters et al., 2000; Winters et al., 2014; Muck et al,. 2001) have been used for the substance abuse treatment for adolescents: (1) 12-step or Minnesota model, (2) therapeutic community (TC) approach, (3) family therapy, and (4) behavioural approaches -cognitive behaviour therapy and each of these are discussed below.

Even though the treatment programs base their ideologies on one of these approaches, it is hard to identify a distinctive model for each of these programs as the treatment contents are not mutually exclusive and they often function as an eclectic or multimodal approach using contents from different approaches. Therefore, these approaches have common features such as: the goals of abstinence during treatment, involvement of individual and/or group therapies to talk about personal drug abuse problems (Winters, 1999), teaching of various skills for behavioural change and addressing life functioning issues including family issues, and building upon strengths (Winters et al., 2014).

12-step treatment approach or Minnesota Model

The 12-step approach, founded within the Alcoholics Anonymous (AA)/Narcotics Anonymous (NA) principles and basic psychotherapy, takes abstinence as the goal of the treatment and views "chemical dependency" as a disease that must be managed throughout life for abstinence (Muck et

al., 2001). The approach incorporates a series of treatment and lifestyle goals and 'step work' through self-help and mutual-help process (Muck et al., 2001). The primary component of this approach is group therapy. Other components include individual counselling, lectures and psychoeducation, family counselling, recreational activities, working through assignments, attendance at AA/NA meetings and aftercare programs (Jainchill, 2000; Muck et al., 2001).

Among the twelve steps, the first five steps[6] are the main focus of the primary treatment, and the remaining steps are attended during aftercare (Nash, 2020; Winters, 1999). The approach emphasises adherence to the 12 steps, sharing experiences with others who have experienced similar problems with substance abuse and dependence, attending meetings and having an AA/NA 'sponsor' who is available any time to provide help and guidance (Jainchill, 2000; Winters, 1999).

The 12-step philosophy and treatment process has commonly been applied in inpatient and outpatient settings, as well as standalone approach (i.e., attending AA, NA, etc.). The 12-step approach has also been widely incorporated into other treatment programs (Winters et al., 2014).

The Minnesota Model is a community-based model with the adaptation of the 12-step approach to the inpatient or residential treatment setting. The Minnesota approach emphasises inpatient or residential care for a few weeks or months with the 12-step meetings and group counselling as the main therapeutic techniques central to the recovery process (Jainchill, 2000; Sussman et al., 2008). Other treatment components include family therapy, self-help groups and AA attendance upon discharge from residential treatment. Traditionally, the focus of the Minnesota model was on the psychoactive substance use disorder with little attention to the associated psychiatric conditions or dual diagnosis. The model has evolved over time and attention to the associated psychiatric and other related conditions is increasing (Sussman et al., 2008).

Therapeutic community (TC) approach

[6] The twelve steps of Alcoholics Anonymous: 1. We admitted we were powerless over alcohol-that our lives had become unmanageable. 2. Came to believe that a Power greater than ourselves could restore us to sanity. 3. Made a decision to turn our will and our lives over the care of God as we understood Him. 4. Made a searching and fearless moral inventory of ourselves. 5. Admitted to God, to ourselves, and to another human being the exact nature of our wrongs. 6. Were entirely ready to have God remove all these defects of character. 7. Humbly asked Him to remove our shortcomings. 8. Made a list of all persons we had harmed, and became willing to make amends to them all. 9. Made direct amends to such people wherever possible, except when to do so would injure them or others. 10. Continued to take personal inventory and when we were wrong promptly admitted it. 11. Sought through prayer and meditation to improve our conscious contact with God as we understood Him, praying only for knowledge of his will and the power to carry that out. 12. Having had a spiritual awakening as a result of these steps, we tried to carry this message to alcoholics, and to practice these principles in all our affairs (Alcoholics Anonymous World Services I. Twelve Steps and Twelve Traditions. 77 ed. U.S.: Alcoholics Anonymous Publishing; 2012).
Note: Adolescents substitute the word "alcohol" with whatever substance they personally struggle with.

Like the Minnesota model, TC is also a community-based therapy in substance abuse treatment and based on the self-help principles and experiential knowledge of the recovery community model (Morral et al., 2004). The treatment in a TC is based on the view that drug abuse is a disorder of the whole person requiring a multidimensional rehabilitation approach in a 24-hour residential setting for adolescents, emphasising the role of the peer community to facilitate growth and psychological change in individuals (Jainchill et al., 1997a). Therefore, adherence to 'community as method' is very important (Jainchill, 2000). The activities in TC are designed to produce therapeutic and educational change in the participants, and all participants are mediators of these changes (De Leon, 2000; Jainchill, 2000). TC is guided by four inter-related views that differentiate among (1) the disorder, (2) the person, (3) recovery, and (4) "right living" (Jainchill, 2000). Drug abuse is considered a disorder of a whole person that may impact cognitive, behavioural, emotional, medical, and/or social functioning. With this notion, individuals are distinguished along dimensions of psychological dysfunction and social deficits rather than drug use patterns (Jainchill, 2000).

Although some TC programs for adults include day treatment, TC for adolescents tend to be long-term residential program, traditionally 6 to 12 months of planned duration. Regardless of the length of the duration, the TC approach is implemented with sequenced treatment progressing from one phase to the next, requiring the adolescent meet the criteria of progress along behavioural, emotional, and developmental dimensions (Jainchill, 2000). Thus, TCs have two unique features: (1) the use of the community itself, which includes social environment, peers, and staff role models, as therapists and teacher in the treatment process and (2) a highly structured, well-defined, and continuous process of self-reliant program operation (Winters, 1999).

In the modified TC model for have adolescents, a wide variety of therapeutic approaches are provided including individual counselling, family therapy, 12-step, life skills and recreational techniques, limited use of peer pressure, less work pressure and more emphasis on education (Jainchill et al., 1995).

Family-based therapy

Family-based treatment approaches emphasises the view that adolescent's family system has an important influencing role in the development and maintenance of substance abuse problems (Winters, 1999). The family therapy approach is based on the therapeutic premise that the family has the most profound and long-lasting role on child and adolescent development. This approach seeks to reduce adolescent's drug use and related behavioural problems by including the adolescent and at least one other parent or guardian or siblings or household members in the therapy, to address the mediating family risk factors such as poor family communication, cohesiveness and

problem solving (Winters et al., 2009). The overall goal of the family-based therapy is to improve family relationships.

The essential components of family-based therapy are derived from the empirically based clinical models tested for adolescent development (Jainchill, 2000), and also this approach integrates other therapies and addresses a range of factors , such as cognitive behavioural therapy (CBT), ecological, social, community and cultural factors (Ozechowski & Liddle, 2000). The planned duration of this family-based therapeutic treatment ranges between 2 and 6 months, and a varying number of therapeutic sessions are provided in varying outpatient settings such as home, therapist's office, a community treatment centre, depending upon the focus of the discussion and the adolescent's condition (Jainchill, 2000).

Recently, there are generally five evidence-based family-based treatments that are being used: Brief strategic family therapy (BSFT); Family behaviour therapy (FBT); Family function therapy (FFT); Multidimensional family therapy (MDFT); and Multisystemic therapy (MST) (Winters et al., 2014). Although the ultimate goal of these family-based approaches is to reduce the adolescent substance use and correct the related behavioural problems through addressing and mediating family risk factors, there are some variations in the way the approaches are implemented.

Family-based therapies can be part of residential treatment or outpatient treatment or standalone in outpatient setting.

Behavioural therapies

Behavioural and cognitive behaviour approaches are the therapeutic techniques based on psychological theories, which focus on the underlying cognitive processes and teaching adolescents coping skills and behaviours to eliminate substance use (Muck et al., 2001). The behavioural therapies synonymously called cognitive therapies or cognitive behaviour therapies (CBT), all consider that thoughts cause behaviours and substance abuse is a learned behaviour (Muck et al., 2001). These therapies work to address thoughts and the resulting maladaptive behaviours through the application of behaviour modification interventions (Muck et al., 2001). The ultimate goal of the behaviour therapy is to teach adolescents to eliminate the substance use and other undesirable behaviours (Winters et al., 2014) and to learn prosocial desirable behaviours including coping and problem solving skills (Muck et al., 2001; Winters et al., 2009).

Cognitive-behavioural therapy (CBT) is based on the view that thoughts cause behaviours and seeks to change thinking process as a way to change behaviour. CBT teaches adolescents to develop self-regulation, coping skills, communication, and problem-solving skills (Winters et al., 2014).

Most of the behavioural and CBT techniques have been an integral part of other therapeutic approaches. All the behavioural therapies are delivered as either stand alone or in combination with other approaches in residential and outpatient settings as part of group or individual therapies.

Recently, there are other behavioural therapies emerging in the treatment of adolescent substance use, such as motivational enhancement therapy (MET) or brief intervention and contingency management (Winters et al., 2014).

2.3 Outcome research by treatment approach

In a comprehensive and updated review, Williams and Chang (2000) extended the literature on adolescent treatment effectiveness and factors related to outcomes where 53 studies were included for the review. The authors found a great variability in the types of treatment programs. However, a greater number of studies on inpatient and residential treatment were included, and inpatient hospital programs (4-6-week), i.e., Minnesota model, appeared to be the most commonly studied programs in their review, followed by outpatient programs. Therapeutic community (TC) was a less common type of treatment with very high rates of dropout rates ranging from 34% to 90%, with a median of 75% among the included studies because of the lengthy structure of this program in residential settings (6-months to 2-years).

We present a review of outcome studies on three more common treatment approaches below.

2.3.1 Effectiveness of 12-step or Minnesota model

There are relatively few studies that have evaluated the effectiveness of the 12-step or Minnesota Model. Some of these studies evaluated treatment effectiveness at 6-month follow-up post-treatment, and found significantly higher abstinence rates among the adolescents who completed the program compared to non-completer adolescents (Alford et al., 1991; Brown et al., 1994; Winters et al., 2000). Winters et al. (2000) examined the effectiveness of Minnesota Model in the treatment of adolescent drug abusers by comparing residential vs. outpatient, and treatment vs. no treatment and non-completer groups. The authors found a significantly better outcomes for those receiving treatment at 6- and 12-months post treatment compared to those who received no treatment (wait-listed) and who did not complete treatment. However, there were no differences between the residential and outpatient groups. The caveat was that the Minnesota model had short treatment duration (usually 28 days) in the residential program, and there was a difference in the treatment dose between residential and outpatient programs. Because of this difference, the two programs were not comparable (Winters et al., 2000).

Two other studies (Kelly et al., 2000, 2002) reported that adolescents from inpatient treatment who attended the 12-step meetings 3 months and 6 months post-discharge showed an enhanced motivation for abstinence, and the modest beneficial effects of 12-step attendance were mediated by these motivations. In a long-term study, Kelly et al. (2008) investigated adolescent 12-step group involvement at 6 months, and at 1, 2, 4, 6, and 8 years following inpatient treatment. This study found that AA/NA attendance was common and intensive early post-treatment but declined sharply and steadily over 8-year period. However, the effects related to AA/NA remained significant and consistent over time, indicating greater early participation was associated with better long-term outcomes.

In a recent experimental study, (Kelly et al., 2016) compared integrated Twelve-Step Facilitation (iTSF) treatment for outpatient youths with Motivational Enhancement Therapy (MET)/Cognitive Behavioural Therapy (CBT), and found promising treatment results for adolescent with SUD relative to MET/CBT. The authors recommended iTSF as useful to achieve longer periods of sustained abstinence.

2.3.2 Effectiveness of therapeutic community (TC)/residential treatment approach:

The TCs for adolescents are delivered in the residential/inpatient setting only. There has been little research on the effectiveness of TC or residential treatment for adolescents with SUD. Earlier in 1980s, and 1990s, some studies, based on the major multimodality studies in the USA such as the Drug Abuse Reporting Program (DARP) and Treatment Outcome Prospective Study (TOPS), evaluated the effectiveness of TC programs for adolescents, and reported improvements in post-treatment substance use, antisocial behaviours and other related outcomes (Jainchill, 2000). TOPS provided evidence that the adolescents who stayed longer in treatment had positive behavioural changes, however, the outcomes were not uniform across age groups or treatment modalities (Grella, 2006). Both studies reported a direct positive relationship between post-treatment outcomes and retention in treatment. Although, adolescents constituted a very small proportion of the sample and majority were adults in both the DARP and TOPS studies (Grella, 2006; Jainchill, 2000), the findings of these two studies shed light on the importance of addressing adolescent-specific treatment issues and the need to examine client characteristics and outcomes by gender, age, ethnicity, type of substance use, and type of treatment received (Grella 2006). However, in their review, Catalano et al. (1990) found methodological weaknesses in the majority of the studies from DARP and TOPS that compared residential and outpatient treatments, such as lack of control groups, small sample sizes, lack of post-treatment follow-ups and small follow-up rates, as well as inconsistencies in age groups. Therefore, the review findings were inconclusive in terms of the superiority of the treatment

approach although some studies claimed TC or residential treatment was better than outpatient treatment for adolescents (Catalano et al., 1990).

Another multimodality study, Drug Abuse Treatment Outcomes Study for Adolescents (DATOS-A) (1993-95), designed specifically for adolescents, had higher rates of adolescents referred by the criminal justice system (Grella, 2006). Studies on DATOS-A reported that the adolescents in short-term and long-term residential treatment had better post-treatment outcomes on some measures, such as reduced marijuana and alcohol use, compared to those in outpatient treatment (Chung et al., 2003; Grella et al., 2001; Hser et al., 2001). With methodological shortcomings including lack of control groups and follow-up rates below 76%, the findings from DATOS-A studies have been difficult to reconcile.

During the 1990s, studies conducted by the Centre for Therapeutic Community Research (CTCR) evaluated TC programs designed for adolescents only (Jainchill, 2000; Jainchill et al., 1995; Jainchill et al., 1997a), and found a significant reduction in alcohol and marijuana use, criminal activities and arrests at one-year follow-up post-treatment, particularly among those who completed the treatment (Jainchill, 2000). However, the quality of these studies in terms of methodological rigor was not high (Tripodi, 2009).

The residential modality has been shown to have better outcomes also for treatment of different types of adolescents. For example, adolescents with a victimisation history had better outcomes in residential programs compared to outpatient treatments (Funk et al., 2003), and adolescents with comorbid mental disorders in residential drug treatment had a significant reduction in post-treatment drug use and improvements in behavioural problems compared to those in outpatient treatments (Grella et al., 2001). However, in a longitudinal study, the adolescents treated in the long-term residential drug treatment have shown the highest relapse rates in one-year post-treatment, despite having a greatest magnitude of reduction in the substance use at one-year post-treatment compared to pre-treatment in this programs (Dasinger et al., 2004).

In a systematic review, Tripodi (2009) assessed the methodological rigor of the studies on effectiveness of TC or residential treatment for substance abusing adolescents. Only eight studies met their criteria, of these seven studies were controlled clinical trials comparing a treatment group and comparison group, while one study had pre-test/post-test design with no comparison group. Of these, four studies were judged to have rigorous methodological quality (they are: Morral et al., 2004; Sealock et al., 1997; Spooner et al., 2001; Winters et al., 2000) with a strong quasi-experimental design and over 70% follow-up rates. Of these most rigorous studies, two found significant differences in substance use reduction between treatment and control groups at 12-

month post-intake follow-up (Morral et al., 2004; Winters et al., 2000), and one found this difference in two-month follow-up, but no difference in 18-month follow-up (Sealock et al., 1997). The less controlled studies were generally unable to detect differences. In this review, Tripodi (2009) developed a list of methodological assessment criteria by borrowing components developed by Miller and Wilbourne (2002) and by Chambless and Hollon (1998), and by giving additional scores to more rigorous designs. However, this mixed set of methodological criteria was not tested for reliability and validity in the quality assessment of the studies.

2.3.3 Effectiveness of family-based therapy:

In recent years, the family-based treatment approach for adolescent substance abuse has gained substantial attention in the research literature. In their review, Ozechowski and Liddle (2000) found that the family-based therapy was one of the most thoroughly studied treatments for adolescents with substance abuse and this therapy has gained substantial empirical support for its efficacy in curtailing adolescent drug use and related behaviour problems as well as addressing comorbid psychiatric disorders.

Austin et al. (2005) reviewed studies on five family-based therapies, Brief Strategic Family Therapy (BSFT), Family Behaviour Therapy (FBT), Functional Family Therapy (FFT), Multidimensional Family Therapy (MDFT), and Multisystemic Treatment (MST), for adolescent substance abuse, which involved random assignment and other rigorous study designs. Of these, MDFT was found to be the most effective treatment for positive outcomes at 1-year post-treatment. The other four approaches also showed improved results compared to the control groups at post-treatment follow-ups.

Similarly, Waldron and Turner (2008) conducted a systematic review of randomised clinical trials evaluating outpatient psychosocial treatments for adolescents with substance abuse since 1998, which included 46 interventions with individual and group CBT approaches, family therapy and other approaches with minimal treatment control conditions. The authors found two family therapy approaches, MDFT and FFT, and group CBT to be efficacious models for adolescent substance abuse treatment. The authors found other approaches as probably efficacious, but none of them appeared to be clearly superior among them for adolescent drug treatment.

2.4 Emerging research foci

2.4.1 Taking a longer-term perspective

During the 1990s and earlier, most studies on adolescent treatment outcomes reported outcomes up to one-year follow-up (Catalano et al. 1990; Williams and Chang, 2000). A few methodologically

rigorous earlier studies (e.g. Morral et al., 2004; Winters et al., 2000) showed encouraging treatment effects at one-year post-treatment for adolescents. However, it is very crucial to understand whether treatment effects last beyond one-year and what would be the long-term substance use and other psychosocial functioning patterns of those who received treatment as adolescents. As the longer-term follow-up data on adolescent treatment outcomes has become available during the last two decades, a growing literature has emerged examining longitudinal data to identify longer-term patterns and trajectories of substance use, and different outcome domains of treated adolescents (Anderson et al., 2010; Brown et al., 2001; Campbell et al., 2016; Chung et al., 2008; Edelen et al., 2010; Godley et al., 2004; Henggeler et al., 2002; Kelly et al., 2008; Larm et al., 2008; Larm et al., 2010; Winters et al., 2007). A majority of the existing literature examining long-term treatment effects and trajectories of adolescent substance use has focused on the first few years (1-4 years) post-treatment, however, most of these studies examining adolescents' substance use trajectories have demonstrated the usefulness of trajectory analysis to identify different groups and their courses of substance use into early adulthood, and also highlighted the need for longer term studies. In recent years, a very small body of literature has emerged to examine longer-term (≥ 5 years) treatment effects on substance use and other related outcomes into r early adulthood or adult lives (e.g. 10 years: Anderson et al. 2010; 7 years: Campbell et al. 2016; 72-102 months: Edelen et al. 2010; 8 years: Kelly et al. 2008; over 15 years: Larm et al. 2008; over 25 years: Larm et al. 2010; 5.5 years: Winters et al. 2007). While some of these studies applied traditional approaches to analyse treatment outcomes and trajectories (Edelen et al., 2010; Winters et al., 2007), recent advancement in latent trajectories approaches seem to be more useful to understand both post-treatment substance use patterns and developmentally important functioning, utilising more information available than with traditional methods (Anderson et al. 2010; Campbell et al. 2016; Chung et al. 2008; Larm et al. 2010). For example, a 3-year post-treatment study by Chung et al. (2008), using latent class mixture modelling, identified different trajectories for alcohol, marijuana and other drug users, and using latent class analysis identified cross-drug patterns of change and also examined conduct disorder and depression as predictors of cross-drug patterns of change. This study found similar cross-drug patterns of change for alcohol, marijuana, and other drugs among the majority of treated adolescents.

In a 10-year follow-up study, Anderson et al. (2010) identified six trajectories based on alcohol and substance use frequency of adolescents treated in inpatient settings using latent class growth analysis, and found more severe drug use trajectories were associated with higher rates of dependence, incarceration, and more treatment during final assessment. Larm et al. (2010) identified four trajectories of resilience using latent growth mixture modelling over 25 years of

adults who were treated as adolescents for substance misuse and compared with a matched comparison group, and found associations of levels of resilience with the severity of substance misuse and delinquency in adolescence. Resilience was defined as absence of adverse outcomes such as substance misuse, hospitalisation for physical and mental illness related to substance misuse, and law-abiding behaviour from ages 21 to 45 years.

More recently, Campbell et al. (2016) identified three trajectories of marijuana users over 7-year post-treatment period using latent curve growth analysis, and examined the association of these trajectories with health services utilisation, psychiatric problems and polysubstance use over time. The authors found, over time, significantly lower average externalising and anxiety/depression scores for Abstinence group compared to the Increasing and Low/Stable groups, fewer psychiatric visits for Low Stable and Increasing group, and use of more substance use treatment services for Low/Stable group compared with the Abstinence group. This study revealed that a group of adolescents, who have greater psychiatric and polysubstance use issues who are at risk of increased use over time, may not be accessing needed services.

Two another methodologically rigorous studies on long-term effects of a residential therapeutic community (Edelen et al. 2010) and the Minnesota approach (Winters et al. 2007) also examined the trajectories of substance use of treatment and comparison groups, using traditional analytical methods such as generalised estimating equation (GEE) and growth analysis with repeated-measure framework. Edelen and colleagues (2010) found positive treatment effects on substance use and psychological functioning at one-year post-treatment, but the treatment effects eroded over time and no evidence of long-term treatment effects was found on all outcomes measured. Similarly, Winter et al. (2007) reported higher levels of drug use among the Treatment and Waiting list groups compared to the Community control at all points of assessment, although the Treatment group had significantly lower levels of drug use than the Waiting list group at follow-up times.

The majority of these long-term studies have highlighted the need for continuing involvement of adolescents in aftercare services for sustained positive treatment effects gained during the initial period after treatment over the long-term.

2.4.2 Addressing comorbid mental disorders

Studies on treatment for adolescents with substance abuse estimate that around 75% of drug-abusing adolescents have a comorbid mental disorder (also known as dually diagnosed adolescents), of which conduct disorder (CD), affective disorder (AD), and attention-deficit hyperactivity disorder (ADHD) are the most prevalent (Brown et al., 1996; Crowley et al., 1998; Grella, 2006). Research

shows that most with CD and ADHD later develop delinquent and anti-social behaviour, often comorbid with SUD (Crowley et al., 1998). Comorbid youth have more problems with family, school, and criminal involvement, and are more likely to be drug or alcohol dependent (Grella et al., 2001). Conduct disorder has also been found to be associated with an early age at onset of substance use (Armstrong & Costello, 2002). Depression is another prevalent mental disorder among substance-abusing adolescents. It has been found that 18% of adolescents using substances have been estimated to have comorbid depression (Armstrong & Costello, 2002), and around 35% depressed adolescents develop substance use disorder (Rao et al., 1999). However, it is often difficult to determine which disorder comes first among comorbid individuals, i.e., which of psychiatric or substance use disorder (Deas, 2006). Several studies have found that adolescents with comorbid mental disorder are at increased risk for relapse after drug treatment (Grella et al., 2001; Kennedy, 1993; Tomlinson et al., 2004), in particular, conduct disorder (Brown et al., 1996; Crowley et al., 1998; Grella et al., 2001; Myers et al., 1995) and major depression (Cornelius et al., 2004; McCarthy et al., 2005) predict higher risk for relapse. Substance use disorders comorbid with depression is a significant risk factor for a range of adverse outcomes and harms including increased rates of adolescent suicide and more substance-related problems amongst those receiving substance use treatment (Deady et al., 2014; Deas, 2006; Lubman et al., 2007). Thus, co-occurring psychopathology, particularly mixed comorbidity (i.e. the presence of both internalising and externalising disorders) has been linked to higher levels of substance-related problems, poorer treatment outcomes, and more severe relapse episodes among treated adolescents (Grella et al., 2001; Kennedy, 1993; Shane et al., 2003).

Thus, earlier studies have attempted to establish the conceptual notion of comorbidity and relationship to treatment, comorbidity, substance use and other related outcomes among treated adolescents. These studies showed heterogeneity in comorbidity and substance use among adolescents, and therefore different subtypes of comorbid adolescents may respond differently to substance abuse treatment (Grella et al., 2001). Treatment approaches for this population therefore need to engage with this complexity. In recent years, a small body of literature has begun to identify effective treatments by evaluating the outcomes of interventions targeting the issues of dually diagnosed adolescents (Babowitch & Antshel, 2016; Bender et al., 2006; Deady et al., 2014).

The majority of the studies on treatment effectiveness have reported high rates of comorbid mental disorder among the adolescents admitted to the residential/inpatient modalities for drug treatment. Although these rates vary from 50% to 80%, the comorbidity prevalence rates can be 2.37 times greater among the adolescents entering residential/inpatient treatment than those in other treatment modalities (Greenbaum et al., 1991). However, very few studies have focused on

examining effectiveness of residential/inpatient treatment specifically on dually diagnosed adolescents (Bean et al., 2005; Crowley et al., 1998; Grella et al., 2001; Grella et al., 2004; Shane et al., 2003). Moreover, these studies have observational pre/post study design and are methodologically weak, and the findings of these studies, therefore, may not be conclusive. In their systematic review of treatment effectiveness for dually diagnosed adolescents, Bender et al. (2006) identified 10 non-randomised studies and 7 interventions with randomised clinical trial design reported across six different studies for dually diagnosed adolescents. Of the 10 non-randomised studies, two studies examined treatment effectiveness of residential/inpatient treatment for comorbid adolescents (Bean et al., 2005; Shane et al., 2003). Shane et al. (2003) suggested that comorbidities can impact negatively on the treatment outcomes in multiple ways including higher relapse rates. In contrast, Bean et al. (2005) showed positive outcomes including significantly reductions in anxiety, depression, CD, and ADHD symptoms and improved family relationships, and educational status from admission to discharge. A further three non-randomised studies which included multimodality settings including residential/inpatient treatment reported negative post-treatment outcomes in substance use (Crowley et al., 1998; Grella et al., 2001; Grella et al., 2004), although some improvements in CD and depression were reported (Crowley et al., 1998).

Outpatient studies have shown mixed results. Among the seven randomised control interventions identified, which had largely family-based and behavioural therapy approaches, Bender et al. (2006) found two interventions, family behaviour therapy and individual cognitive problem-solving therapy, with large effect sizes across externalising and internalising, and substance abuse outcomes in dually diagnosed adolescents.

Two systematic reviews (Babowitch & Antshel, 2016; Deady et al., 2014) examined adolescent treatment outcomes for comorbid depression and substance misuse. Babowitch and Antshel (2016) found some evidence in support of the efficacy for CBT, MET and FFT in the treatment of comorbid depressive and substance use disorders for adolescents, and they also found support for the potential mediators that may have played a role in the mechanism of reducing comorbid symptoms of depression and substance misuse in adolescents. The review by Deady et al. (2014) found that more of the studies (60%) identified had conducted pharmacotherapy trials with less focus on the psychotherapeutic treatment components, but these pharmacotherapies appeared no better than placebo. The authors assert that there are very little evidence-based intervention trials for treating co-occurring depression and substance use in youths, and this requires further research to identify more innovative interventions.

2.4.3 Gender differences

An examination of treatment admission data from 2008 in the USA shows that adolescents who enter treatment for substance use disorder are diverse with around 30% being female, and has identified differences in drug use patterns of males and females. Among the admitted to treatment, more females than males were White, and 37% of adolescent females were referred by juvenile justice system compared with 53% of males (Godley et al., 2011). Some earlier studies (Hser et al., 2003) have shown that female start using alcohol and other drugs at a later age than male adolescents, however, studies on adult drug use treatment outcomes have reported that men and women start their drug use and treatment career at similar age (Hser et al., 2003). Female adolescents seeking treatment generally have a greater degree of psychiatric problems, histories of physical and sexual abuse, and a smaller proportion of them are referred by juvenile justice system, whereas males have higher rates of illegal activity, involvement with the juvenile justice system, and higher rates physical abuse (Grella, 2003; Jainchill et al., 1997b; Rounds-Bryant et al., 1998). Literature showing gender differences among adolescent substance abusers indicates that (1) boys are more likely to initiate drug use earlier and to use a greater quantity than girls, (2) conduct disorder predicts later drug use for both genders and internal disorders for girls, and (3) there is positive association between poly drug use, depression and normlessness for girls. Treatment programs for adolescents need to be gender responsive and must include activities focusing on specific female issues (Grella, 2008; Jainchill, 2000). However, literature on gender differences in adolescent substance use treatment and outcomes analysis is limited.

While substance abuse treatment outcomes for adolescents have generally demonstrated reduction in alcohol and drugs use following treatment, the results may differ between males and females in many domains. Stevens et al. (2004) reported that, at intake, females had significantly greater severity in substance use including problems associated with use, and greater mental health problems, while males had significantly more days on probation or parole at intake. The results during 30-month follow-up period showed that the rate of change in mental health and days on probation/parole were found to be different between the sexes, but there was positive change following treatment for both groups in relation to substance use, mental health, and probation/parole. Another study indicated that females have better attendance in aftercare or self-help groups and better treatment outcomes than males, and the attributes such as school problems, legal problems, lack of religious involvement, and substance abuse before treatment for females, and substance abuse before treatment, length of stay, and parental participation in treatment for males could differentiate abstinence status between males and females at post-treatment follow-up (Hsieh & Hollister, 2004). Godley et al. (2011) examined gender and racial differences in treatment

initiation, engagement, dosage, treatment satisfaction, and outcomes for adolescents, who received the Adolescent Community Reinforcement Approach (A-CRA) using data from the USA. Results showed no significant differences for initiation, engagement, or retention by gender or race, however, male adolescents had significantly higher rates of treatment satisfaction than female adolescents, and African American adolescents had significantly higher rates of treatment satisfaction than Caucasian adolescents. While all racial groups showed significant increase in days abstinent from alcohol and other drugs, female adolescents had a higher percentage of days abstinent from alcohol and other drugs and were more likely to be in recovery at the six-month follow-up than male adolescents. It was concluded that the intervention was well implemented across gender and racial groups and equally effective across racial groups at six months. This study results underscores the importance of gender responsive treatment process and after care for the positive outcomes for both sexes, however, the outcomes examined were for short-term post-treatment, and it is unknown whether the positive outcomes gained initially continued to last for a longer time period.

2.4.4 Ethnicity and cultural sensitivity

Literature from the USA on the effectiveness of drug abuse treatment for adolescents in both residential and outpatient settings have shown patterns of drug use among different racial groups, particularly among the African-American, Caucasian White, and Hispanic groups. However, little is known about adolescents substance users from minority ethnic groups such as Hispanic, America-African, Native-American, and other indigenous groups from other countries including Australia, and the effectiveness of treatment for them, because these adolescents are generally not involved in the clinical studies of substance abuse treatment, or likely to be in a very small number when they are included, or/and the results of these groups are not presented (Rounds-Bryant & Staab, 2001). Studies have indicated that the prevalence of substance use among the minority youth is comparable to that of Caucasian White youth, with minority being more likely to report using alcohol and marijuana than other drugs, similar to Whites (Dembo et al., 1994; Swendsen et al., 2012). In contrast, other studies indicate that African-American and Hispanic youth tend to report higher rates of substance use and mental health problems than Whites (Wells et al., 2001). Some research also suggests that Native American youth are at elevated risk for problem drinking, specifically heavy or binge drinking behaviour than other groups (Boyd-Ball, 2003). Thus, the literature presents conflicting results on the groups with highest prevalence of substance use. The prevalence and patterns of substance use among these ethnic youths are yet to be well researched. There is also scepticism about the efficacy of the current substance use treatment programs for the

ethnically diverse adolescents because the current literature does not provide clear empirical evidence on treatment effectiveness for minority youths (Burrow-Sanchez et al., 2011).

There is a consensus in the literature that substance use treatment programs need to have cultural modification for ethnic minority adolescents (Boyd-Ball et al., 2011; Boyd-Ball, 2003; Burrow-Sanchez et al., 2011; Burrow-Sánchez et al., 2015). However, research is lacking regarding the examination of ethnicity in controlled treatment outcomes involving ethnically diverse adolescent substance users (Strada & Donohue, 2006). In their review, Strada & Donohue (2006) reported that, despite 94% of the outcome studies described ethnicity, only 28% of these studies incorporated ethnicity in their design and only 6% had analysis examining differential response to treatment or moderating effects of ethnicity by including ethnic minority participants in sufficient numbers in the study. The authors found rare evidence from the studies in their review for any modifications made to the treatment components to accommodate ethnicity-related variables.

Studies have reported that the treatment completion rates among minority youth is lower than non-minority groups, e.g. leaving treatment without professional advice is common for Hispanic and Asian-Americans groups than White groups, which could be linked, among others, to dissatisfaction with the quality of treatment or to low cultural components in the treatment programs (Saloner et al., 2014). Some studies have been conducted to identify and develop models that accommodate culturally responsive and family-enhanced variables for substance use treatment for minority youths (Boyd-Ball, 2003; Burrow-Sanchez et al., 2011). A small number of outcome research studies examined the efficacy of culturally modified substance use treatment interventions for minority youths have highlighted the importance of accommodating ethnic identity, acculturation, and familial variables in treatment in reducing substance use after treatment because these variables played important roles as moderators. A study examining the effects of psychopathological peer, family, and cultural predictors of American Indian adolescents' drug use following inpatient treatment suggested that a combination of family management and American Indian traditional cultural practices in families served as a potential target for interventions to reduce substance use in adolescence (Boyd-Ball et al., 2011). Similarly, two studies examining effectiveness of treatment for Latino adolescents by comparing empirically supported standard version of cognitive-behavioural substance abuse treatment to a culturally accommodated version (Burrow-Sanchez & Wrona, 2012), and by comparing standard version of a group-based cognitive-behavioural treatment to a culturally accommodated version with a sample of Latino adolescents primarily recruited from the juvenile justice system (Burrow-Sánchez et al., 2015), have found a significant decrease in substance use from pre- to post-treatment, however, these outcomes were moderated by ethnic identity and familyism.

2.4.5 Therapeutic engagement and retention in residential treatment

Therapeutic community (TC) residential treatment for adolescents with SUD has been shown to have positive post-treatment outcomes in substance use, psychosocial functioning, criminal behaviour, and comorbidity (Jainchill et al., 2005; Morral et al., 2004; Sealock et al., 1997; Sealock & Manasse, 2012; Williams & Chang, 2000; Winters et al., 2000). Despite the success of the TC in reducing substance use and other outcomes, adolescents have high treatment dropout rates, which has been a significant problem. Studies have shown various risk and protective factors, broadly categorised as pre-treatment factors (e.g., demographic characteristics, history of abuse, comorbid mental disorder, substance use severity at admission, low self-esteem), during treatment factors (e.g., the content of the intervention provided, engagement in treatment, and length of stay), and post-treatment factors (e.g., broad range of psychological, social, and environmental variables that occur following treatment) that are associated with treatment outcomes (Catalano et al., 1991; Williams & Chang, 2000). Studies have documented that treatment retention or a longer time in treatment are related to more positive outcomes, similar to adults (Brown et al., 1994; Jainchill, 2000). Treatment retention has also been shown to significantly decrease relapse rates among adolescents (Hser et al., 2001; Jainchill, 2000; Sterling et al., 2009). In residential treatment, 3 months' stay has been regarded as the required treatment length to obtain positive outcomes (Amodeo et al., 2008; Simpson & Joe, 2004). Therefore, it is important to understand the factors that affect early engagement of adolescents in the treatment process. In recent years, studies have emerged to examine the treatment process, therapeutic engagement and retention among adolescents in residential treatment, which are linked to the post-treatment outcomes (Abdel-Salam, 2014; Amodeo et al., 2008; Edelen et al., 2007; Gunter & Abdel-Salam, 2014; Hawke et al., 2005). Research has shown that therapeutic involvement and services provided during treatment are among the best predictors of treatment retention, and thus indirectly associated with post-treatment outcomes via treatment retention (Hawke et al. 2005). Motivation and readiness for treatment is shown to be an important predictor of therapeutic engagement and of treatment success (refs). Adolescents who are motivated tend to be more ready for recovery from substance use and experience more positive outcomes (Abdel-Salam, 2014; Breda & Heflinger, 2007).

Although the positive impact of treatment retention on post-treatment substance use is documented in the literature, there is limited research on program-level treatment processes, in TC approaches in particular, to understand the factors related to r treatment retention and positive outcomes. Edelen et al. (2007) examined associations of a new multidimensional measure of therapeutic TC treatment process using the Dimensions of Change Instrument (DCI) with treatment retention and post-treatment outcomes among adolescent residential clients, and found

adolescents who increased during the first 30 days in treatment on three of the eight DCI factors (Positive Self-Attitude and Commitment to Abstinence; Problem Recognition; Social Network) were more likely to stay in treatment for 90 days or more. Staying in treatment for 90 days or more increased the likelihood of attending 12-step meetings and having a 12-step sponsor after leaving treatment. Several demographic and pre-treatment characteristics also predicted retention, post-treatment outcomes, or both, for example, those who stayed 90 days+ were more likely to be White (compared to Hispanic) and more likely to be referred by criminal justice system, those with no arrest history were more likely to be abstinent.

Gunter and Abdel-Salam (2014) analysed a path model hypothesizing that therapeutic engagement would increase the chances of remaining in TC treatment that, in turn, would decrease the chances of post-treatment substance use in adolescents. Results suggested that those more engaged in treatment are more likely to complete treatment, and therefore less likely to use substances after discharge.

The results of these limited studies indicate that much remains to be learned about how the TC treatment process produces positive outcomes for adolescents with SUD.

2.4.6 Continuing care and recovery support

The majority of the studies examining long-term treatment outcomes report eroded or no treatment effects in the long-term (≥5 years), and highlight the importance of continuing care after treatment to maintain long-term treatment effects on substance use and other related outcomes for adolescents (Campbell et al., 2016; Edelen et al., 2010; Larm et al., 2010; Sterling et al., 2009; Winters et al., 2007). A small body of literature has emerged to investigate the effects of continuing care, such as Narcotics Anonymous/Alcohol Anonymous (NA/AA), Adolescent Community Reinforcement Approach with Assertive Continuing Care (A-CRA/ACC), 12-Step and self-help groups, on the outcomes for adolescents and young adults (Bergman, Greene, Hoeppner, et al., 2014; Bergman, Greene, Slaymaker, et al., 2014; Bergman et al., 2015, 2016; Hawke et al., 2008; Kaminer et al., 2008; Kaminer et al., 2013; Kaminer & Godley, 2010; McGarvey et al., 2014). Although these studies have found, in general, that active aftercare interventions have positive effects on reducing substance use and slowing relapse process, the results are varied. For example, Kaminer et al. (2008) found that the aftercare was effective for maintenance of outpatient treatment gains only for girls for their alcohol use problems. The authors also reported that, at the end of the aftercare, the likelihood of relapse increased significantly compared with end of treatment outcomes. On the other hand, McGarvey et al. (2014) found that A-CRA/ACC is effective in reducing cannabis and alcohol use

over time among the adolescents; however, the design of this study was limited to the treated adolescents only.

In sum, this study identified research gap and the limitations in the current literature of AOD use treatment and treatment outcomes of young people with problematic AOD use through a thorough review in this chapter as well as in the previous chapter. Although there is a growing body of research on evidence-based treatment approaches and outcomes, there is a gap in the research on the long-term outcomes of adolescents referred to a residential treatment with a Therapeutic Community (TC) approach. Addressing this gap, this research focuses on the three long-term outcomes of adolescents referred to a residential modified TC program: mortality outcome, and AOD- and MH-hospitalisation outcomes of young people using linked data following up to 16 years. In the next chapter (Chapter 3) of this dissertation, I describe the methods used for each outcome study in brief because the detailed specific methods of each study have been provided in the corresponding study (Chapter 4-6).

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CHAPTER 3: Methods

Using secondary data from adolescents (13 to 18 years) referred to a residential TC treatment program (PALM) for problematic AOD use, the purpose of this research was to determine evidence on long-term effectiveness of residential TC program for adolescents with problematic AOD use. For this purpose, this study investigated mortality, AOD use, and mental health outcomes adolescents, using longitudinal linked data on mortality and hospital admissions following up to 16 years post-PALM. There were three overarching aims of this study: (1) estimate mortality rates and determine causes of death among adolescents, (2) determine overall AOD hospitalisation rate for the cohort, identify distinct subgroups of adolescents in the sample with distinct developmental trajectory patterns of AOD-hospitalisations from adolescence through to adulthood, and determine predictors of each trajectory class, and (3) determine overall mental health related hospitalisation rate for the cohort, identify distinct subgroups of referred adolescents with distinct trajectory patterns of mental health related hospitalisations from adolescence into adulthood, and determine predictors of each trajectory class.

This chapter presents the overall study design and ethics approval, participants, data linkage treatment setting, statistical analysis and anticipated outcomes. The specific methods used for each study conducted to address Aim 1- Aim3 are presented in the next corresponding chapters (Chapter 4- Chapter 6).

3.1 Research design and participants

This is a consecutively enrolled and retrospective cohort study of young people (13-18 years) who were referred to a Ted Noffs' residential TC program called PALM (Program for Adolescent Life Management) for problematic AOD-use in New South Wales (NSW) and the Australian Capital Territory (ACT), Australia. Participants for this study were referred and assessed at PALM consecutively from 2001 to 2016. Some participants may have multiple referrals and assessment during this study period (2001 to 2016). The study population comprised all adolescents who were referred and assessed by expert staff at PALM for their eligibility for treatment.

The PALM database consisted of 3639 adolescents, both males and females (sex at birth). However, the analytical sample required exclusion of some participants due to not meeting eligibility criteria for this study. The exclusion criteria included: assessment date (or admission date if the assessment date was missing) not within the study period (1 January 2001- 31 December 2016); if not aged 13-18 years at time of assessment; and if both assessment and admission dates were missing. Of 3639

participants, 110 were excluded. Of those excluded, 74 had assessment dates outside the study period, 31 met at least one of the other exclusion criteria, and an additional five had data entry errors in the hospitalisation records. Therefore, the analytical sample for the hospitalisation data analyses in Chapter 5 and Chapter 6 included 3529 participants.

However, the analytical sample for the mortality analysis in Chapter 4 included 3256 participants due to slightly different exclusion criteria for that study. The participants referred to PALM between January 2001 and June 2015 were included for this study providing at least 1.5 years follow-up period for those who were referred in 2015 because the mortality linked data for ACT were incomplete or unavailable for some participants due to coroner cases, although the dataset for NSW was complete. To reduce the biasness, I used data until June 2015 for the mortality analysis. Of 3639 clients, 383 subjects (352 with assessment dates not within January 2001–June 2015 period, and 31 meeting at least one of the other exclusion criteria) were excluded (Figure 1).

The sample for this dissertation included two main groups: those who were referred and attended PALM treatment (treatment attend group); and those who were referred and assessed but did not attend the treatment (non-attend group). Although detailed and consistent data were not available on reasons for not-attending the program, the recorded reasons often included: eligible but being refused bail, or eligible but did not attend due to loss of interest, or assessed as not being eligible either due to higher severity of the problems or not meeting DSM-IV criteria (Dixson et al., 2018; Nathan et al., 2020). Participants were mainly referred by the juvenile justice system, case workers, clinicians, or some by self, family or friends, and assessed by service staff for their eligibility for treatment using Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) criteria for substance abuse and substance dependence, including comorbid mental health and behavioural problems. Since many of this cohort were referred by juvenile justice or had a history of criminal activities and court involvement, one of the main reasons for non-admission in non-attend group were being refused bail (Bista et al., 2021; Dixson et al., 2018; Nathan et al., 2016).

Several participants of the sample had multiple treatment assessment or admission to PALM during the study period. The PALM program used a 30-day rule to define treatment episode. That is, re-admission within 30 days or less from the discharge date of previous treatment was counted as the same episode, and after 30 days as a new episode. This definition of episode was used also in previous research (De Leon, 2000).

3.2 Ethics approval

This proposed study is being conducted as part of an existing research project which has ethics approval from the NSW Population Health Ethics Committee: 2015/10/616; ACT Health Department Ethics: ETH.11.15.216 and the Aboriginal Health and Medical Research Council Ethics: 1144/15 (over 30% of the sample identify as Aboriginal). Ratification was obtained from the UTS Human Research Ethics Committee. After all data custodians provided an approval to access their data sets, the data linkage process was undertaken by the Centre for Health Electronic Record Linkage (CHeReL). After data-linkage process was performed, the de-identified data were provided to the research team.

3.3 Data linkage and rationale

The complete database of clients of the PALM program from 2001 to 2016 from NSW and ACT sites. was linked to administrative data from the NSW and ACT Mortality data, and NSW and ACT Admitted Patient Data Collections. Approximately 4500 consecutive referrals to PALM during 2001-20016 were linked to the administrative data sets, including those who are referred and attended the PALM program, and those who are referred but did not attend the PALM.

In order to develop a more complete picture of the true extent and impact of alcohol and drug use among this group, the use of multiple and complementary data sources is necessary. Data linkage has become increasingly useful to assess outcomes in the health and criminal justice sectors, although studies using data linkage have been largely focussed on adults (Nathan et al., 2016). While linked data possess some limitations such as data errors, missing entry data, mismatching of records, and non-randomly allocated comparison groups, there are many advantages of using linked administrative data. These advantages include the ability to obtain data on large number of clients for a longer period of time across several outcomes with minimised cost and loss to follow-up (Alterman et al., 2001; Hser & Evans, 2008). Traditional follow-up studies using surveys and interviews with this group often have poor response rates (Nathan et al., 2016). A linked data study with adolescents has the potential to significantly contribute to policy, prevention and treatment fields across the health and criminal justice sectors.

3.4 PALM treatment setting

Program for Adolescent Life Management (PALM) is an intensive residential program for adolescents aged 13-18 years with alcohol and/or other drug-related problems. PALM provides a modified therapeutic community (TC) treatment approach in a residential setting for adolescents for up to three months, and continuing care for up to 3 years post-PALM. Some adolescents can stay at

treatment for longer on clinical advice with four months usually the maximum time allowed in the program. PALM aims to help young people to build the skills to manage their own lives effectively. Based on Australia's National Drug Strategy (https://www.health.gov.au/resources/collections/national-drug-strategy), PALM takes a harm reduction approach, as opposed to a complete abstinence approach, and provides a holistic, intensive and multi-disciplinary treatment program with an ultimate goal to build a positive path for young people's life outside the program, including stability in accommodation, employment and positive social and family networks.

PALM is staffed 24 hours a day and operates out of two residents in Sydney and ACT. Each PALM has a capacity ranging from 8-16 young people at any one time (Noffs Foundation, www.noffs.org.au). Participants are referred to PALM by the youth justice system/court, police, case workers and clinicians or by family or self-referral and assessed by expert staff for their program eligibility using the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) criteria for substance abuse/dependence over the past 12 months (Foster et al., 2010; Nathan et al., 2016).

What is PALM treatment?

PALM provides a holistic, intensive, multi-disciplinary, residential program staffed by professionals specifically trained in dealing with trauma, challenging behaviours and complex needs. Treatment at PALM consists of three main areas: counselling, vocational education (voc-ed), and living skills. Other treatment components include family support, group work, and recreational activities. Treatment is completely client driven so that the young people can decide what they want to change and then set goals to achieve this. Each young person has an individual treatment plan tailored to his or her specific needs based on a thorough assessment. The holistic approach encourages young people to address their drug use through various activities. Treatment helps to address problematic drug use, mental health, family dysfunction and criminality issues, and to establish links to education and/or work and teaches life skills including assertiveness and the management of problematic behaviour such as anger management. PALM views that, since drug use is tied to other aspects of people's lives, simply sorting out the drug use itself is ineffective if the other areas that contribute to problematic drug use are not dealt with. A holistic approach is necessary to make sure any change in a person's drug use is positive and sustainable. As a result, each program addresses issues such as employment, training, relationship building, mood management, personal growth and development, and teaches relapse prevention skills (Noffs Foundation, www.noffs.org.au). PALM aims to provide assistance in all areas of personal growth and development, personalising each service as much as possible, to account for each individual and their difficulties. The program attends to the physical

needs of the participants such as their nutrition, health, sleep and exercise (Noffs Foundation, www.noffs.org.au).

PALM program uses modified therapeutic community (TC) approach for adolescents, which is typically rooted in self-help principles and experiential knowledge of the recovery community. This treatment approach views the community as the key agent of change and emphasizes mutual self-help, behavioural consequences, and shared values for a healthy lifestyle (Winters et al., 2018). The rationale behind PALM is that it is not enough to simply reduce or eliminate drug use.

3.5 Measures

Outcome variables

The outcome variables were number of number all-cause mortality for the mortality analysis (Chapter 4), and the number of AOD-hospitalisations (Chapter 5) and the number of mental health related hospital admissions (MH-hospitalisations) (Chapter 6) during the study period. All the outcomes were post-treatment measured from the exit day from the PALM residential program (or assessment date if not enrolled) until 31 December 2016 or death if occurred before this date. The ICD-10-AM codes for causes of death, and for both AOD-hospitalisation and MH-hospitalisation outcomes were used, and these codes and other details of how these outcomes were measured are provided in each corresponding study from Chapter 4-Chapter 6.

Exposure variable

For all three studies (Chapters 4-6), the exposure variable was the length of stay (LOS) at PALM. Length of the exposure to PALM program for the participants was measured by the days in the residential program received before MH-hospitalisation follow-up began, and categorised in three groups as: (a) ‘days>30’, who stayed in program over 30 days up to three months (40.1%, n= 1414), (b) ‘days≤30’, who stayed four to 30 days, not completing program as planned (24.9%, n=877), and (c) ‘non-attend’, who were referred/assessed but did not attend program or attended only up to 3 days (35.1%, n=1238). The ‘non-attend’ group was the comparison group for the analysis.

Pre-program covariates

The covariates or factors known to be associated with program engagement and retention which is likely to then influence outcomes in the long-term used for this study included: age at referral; sex at birth (male/female); identifying as Aboriginal and/or Torres Strait Islander Australians (herein referred to as ‘Aboriginal Australians’ as the term recommended by Aboriginal Health and Medical

Research Council for NSW (Aboriginal Health and Medical Research Council, 2015)) (dichotomised: Aboriginal/non-Aboriginal); pre-program involvement of youth justice system (justice department or court) or police (dichotomised: justice-involved/non-involved); psychological symptoms measured by Brief Symptoms Inventory (BSI) Global Severity Index (GSI) T-score (dichotomised: GSI<63/GSI≥63) from (Derogatis, 1993); DSM-IV substance dependence score (dichotomised: score≤5/score>5), and principal drug of concern (DoC) at referral (categorised: opioids; cannabis/hallucinogens/tranquilisers; alcohol; and amphetamines/ERD/cocaine/inhalants). Number of places lived last six months (dichotomised as: 1-2 places vs 3-7 places) was also measured. The descriptions of these covariates are provided in Supplementary Appendix 2.

3.6 Statistical analysis

Data linkage allowed for perform longitudinal studies for this research following up to 16 years post-treatment. Detailed statistical analyses approaches applied for each study for each aim (Aim 1- Aim 3) are provided in respective chapters (Chapter 4-6). In general, in each study, descriptive analyses were performed using chi-squared tests or ANOVA tests, showing the group differences across the variables. In each study, appropriate statistical analyses were performed to answer the research questions set to address the respective aims. Statistical analyses were conducted using SAS, R, and Mplus Version 8.7.

In brief, for the mortality analysis (Chapter 4), I calculated crude mortality rates (CMRs) using person-years approach, and standardised mortality ratios (SMRs) using NSW general population and standardised by age, sex, and calendar-year for the study period (2001-2016). These rates were calculated for the cohort and across the demographic and pre-treatment variables. Causes of deaths were analysed using ICD-10 codes.

For both AOD-hospitalisation and MH-hospitalisation studies (Chapter 5-6), statistical analyses were performed in three stages. In the first stage, crude hospitalisation rates (AOD-hospitalisation and MH-hospitalisation) were calculated using person-years for the cohort and across the demographic and pre-treatment variables. I also estimated adjusted rates (adjusted for age, sex, Indigenous status, and treatment variables) for both hospitalisations using regression analysis, for which negative binomial regression for count data was used due to over-dispersed count outcomes. Other variables were not used in the adjusted models due to missing data.

In the second stage for both studies (Chapter 5-6), trajectory analyses were performed to identify the heterogenous longitudinal trajectory patterns of AOD-hospitalisations and MH-hospitalisations of young people referred to PALM treatment over time from adolescence through to young

adulthood and adulthood. For these analyses, I used growth mixture model (GMM), which is a recently advanced person-centred approach for longitudinal data and identifies subgroups by considering the existence of unobserved heterogeneity among the individuals. The traditional growth modelling approaches such as multilevel, random-effects model, give a single average growth estimate, however, there may exist a subset of individuals whose growth trajectories are significantly different from the overall estimate. GMM, on the other hand, models different growth pattern of heterogenous subgroups by identifying different latent trajectory classes (Jung & Wickrama, 2008; Muthén & Muthén, 2000). GMM was performed to explore different class solutions from one-class to five-class models and model selection criteria were used the optimal class solution for the data. Model selection criteria and process has been described in Supplementary Appendix 3.

In the third stage, to analyse the association of demographic and pre-treatment predictors with those identified trajectories, a predictive model using multinomial logistic regression, incorporating BCH method in Mplus (Asparouhov & Muthén, 2014a, 2014b), was conducted. Odds ratios and significant estimates of the variables were reported.

Missing data

Missing data in the hospitalisation outcome variables (Chapter 4-6) due to study design (i.e., consecutive enrolment in the treatment during study period) was considered a missing at random (MAR) for trajectory analyses and handled using the full information maximum likelihood (FIML) estimation with robust standard errors in Mplus. For the missing data in the predictors, multiple imputation approach was used using BCH method in Mplus (Asparouhov & Muthén, 2014a, 2014b). See Supplementary Appendix 3.

3.7 References

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CHAPTER 4: Mortality among young people seeking residential treatment for problematic drug and alcohol use: a data linkage study

4.1 Preamble

Despite evidence showing higher premature mortality among the AOD treated adult population (Abdul-Rahman et al., 2018), with mortality ranging from four to fourteen times higher compared to the general population (Åhman et al., 2018; Arendt et al., 2011; Degenhardt et al., 2011; Finney et al., 1999; Lindblad et al., 2016), there is a lack of evidence on mortality of young people referred to treatment for AOD use. This is the first study among three outcome studies in this thesis, which focuses on investigating mortality rates and patterns, and causes of death among the referred young people following up to 16 years post-PALM. This study was published in Drug and Alcohol Dependence.

4.2 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 (28838 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.

4.3 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 & 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; Degenhardt et al., 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), there is limited evidence on mortality of 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 & 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; Larm et al., 2008; Larm et al., 2010; McCarty et al., 2004), health problems (Mertens et al., 2007; Schulte & Hser, 2013), suicidal behaviour (Bukstein et al., 1993; Pompili et al., 2012), and death (Hodgins et al., 2009; Larm et al., 2015; Larm et al., 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; Winters et al., 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; Nathan, Rawstorne, et al., 2016; Tripodi, 2009). Young people in residential treatment in Australia and the US have been found to have complex histories, including trauma and comorbid psychiatric conditions (Dixson et al., 2018; Nathan, Bethmont, et al., 2016; Neumann et al., 2010; Vourakis, 2005), family histories of problematic AOD use (Blood & 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., 2007; Albertella & 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 et al., 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; Larm et al., 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.

4.4 Methods

4.4.1 Study design and participants

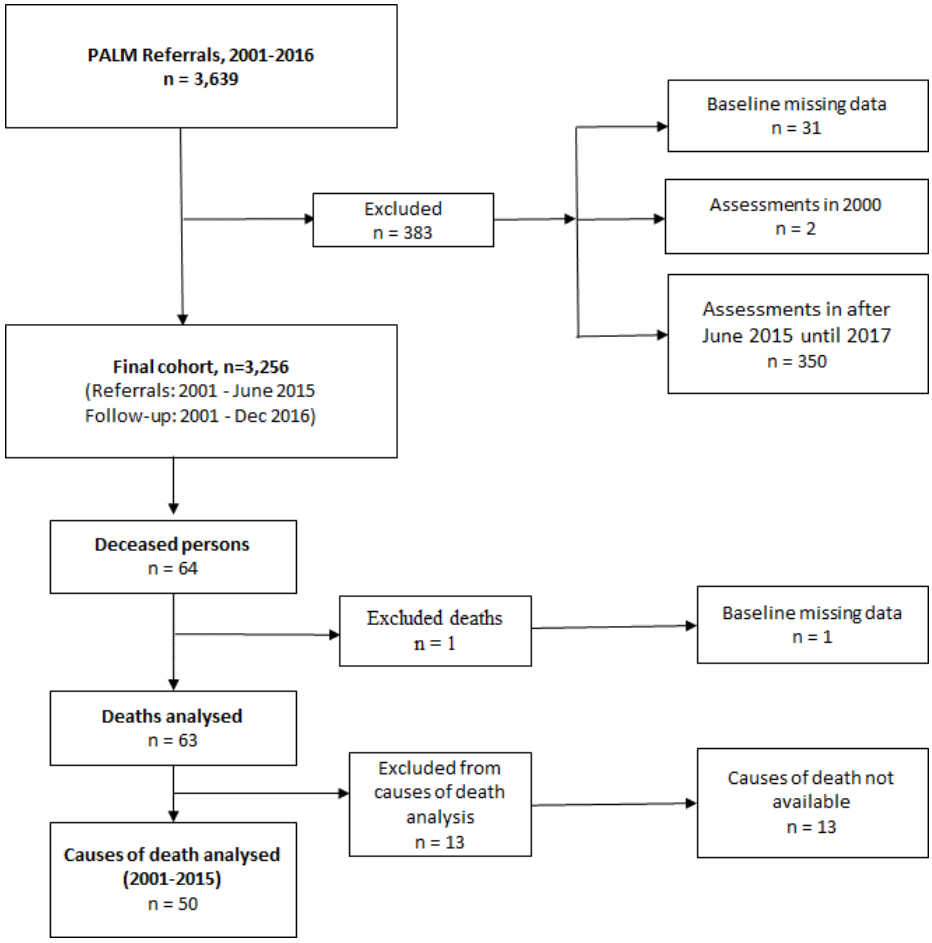
This study examined mortality among young people (aged 13-18) referred to residential treatment for problematic AOD use. The study population comprised all young people referred and assessed at the Ted Noffs' Foundation treatment program (Program for Adolescent Life Management - PALM) in New South Wales (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) (Figure 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).

Figure 1: Flowchart of participants in the study cohort and mortality analysis, 2001-2016



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

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.

4.4.3 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 (Figure 1).

4.4.4 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).

4.5 Results

4.5.1 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 28838 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 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).

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).

4.5.2 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.

4.5.3 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).

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	28838	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)	
15-16	1585 (49%)	-	-	-	1.72 (1.2-2.6)	4.06 (2.6-5.9)	0.232
17-18	1385 (42%)	-	-	-	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%)	-	-	-	2.28 (1.5-3.4)	4.52 (3.0-6.5)	
GSI T-score ≥ 63 (Males)	293 (12%)	-	-	-	3.43 (1.7-6.8)	6.72 (3.1-12.5))	0.345
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%)	-	-	-	2.17(1.5-3.2)	4.29 (2.8-6.2)	0.078
PST T-score ≥ 63 (Males)	212 (9%)	-	-	-	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%)	-	-	-	2.61 (1.8-3.8)	5.16 (3.5-7.3)	0.578
PSDI T-score ≥ 63 (Males)	319 (14%)	-	-	-	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 to purge the smaller observed deaths.

[b] Percentages were out of those who responded to the respective questions and the deaths in each group.

4.5.4 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.

4.5.4.1 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).

4.5.4.2 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).

4.5.4.3 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).

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 drug 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.

4.6 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; Jainchill et al., 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 & 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, particularly amongst 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., 2005), 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; Nathan, Bethmont, et al., 2016; Nathan et al., 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 & Cornwall, 1994; Dasinger et al., 2004; 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; Degenhardt et al., 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.

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.

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 causes 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.

4.7 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.

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CHAPTER 5: Trajectories of alcohol and drug related hospitalisations of adolescents referred to a residential program for problematic alcohol and drug use: A longitudinal linked data study

5.1. Preamble

The previous study in Chapter 4 provided evidence of an elevated mortality rates in the cohort. The study in this chapter focuses on the AOD-related morbidity of adolescents using longitudinal hospitalisation linked data following up to 16 years post-PALM to provide evidence on long-term AOD-related hospitalisations among the referred young people. More specifically, this study investigates AOD-related hospitalisation rates in the cohort and across the demographic characteristics, distinct patterns of AOD-hospitalisation trajectories over time among different subgroups of participants and the pre-treatment predictors of those trajectories. The implication this study lies on helping service providers identifying high-risk subgroups and their characteristics at early screening and design AOD programs addressing their complex treatment needs. This study has been submitted to Drug and Alcohol Dependence and currently under review.

5.2 Abstract

Background: Long-term alcohol and other drug (AOD) use patterns of adolescents referred to residential AOD-programs are less known. We investigated long-term post-program AOD-hospitalisation trajectory patterns and associated risk-factors.

Methods: Adolescents (13–18 years) referred to residential program (n=3529) were followed up to 16 years post-program using hospitalisation data-linkage. AOD-hospitalisation crude rates were estimated. AOD-hospitalisation trajectories were identified using growth mixture modelling (GMM). Risk-factors associated with trajectories were examined using multinomial logistic regression.

Results: The sample (73% males; 43% Aboriginal Australians; median referral-age=16.8 years; median follow-up=8.11 years) had 5415 AOD-hospitalisations. Overall AOD-hospitalisation crude rate was 188/1000 person-years [95% CI: 183.16-193.22]. Crude rates were higher for females, older-group, Aboriginal Australians, those with greater psychological distress (GSI≥63), program-attending groups (days≤30, days>30), and lower for justice-involved participants. GMM identified three AOD-hospitalisation trajectories; one-thirds exhibited poorer outcomes (*high-decreasing* and *increasing* trajectories). Predictors of *increasing* trajectory (vs *low-to-zero*): older-age (OR =1.25 [1.01-1.53]), Aboriginal Australians (OR =4.35 [2.60-7.31]), females with GSI<63 (OR =2.54 [1.35-4.78]), males with GSI≥63 (OR =2.38 [1.13-5.0]), cannabis/hallucinogens/tranquilisers (OR =3.64

[1.83-7.24]) and opioids as drug of concern (DoC), justice-involvement (OR =0.27 [0.01-0.53] among days≤30; OR =0.51 [0.15-0.86] among days>30). Risk-factors predicting *high-decreasing* trajectory (vs *low-to-zero*): those with GSI≥63, Aboriginal Australians, opioids and cannabis/hallucinogens/tranquilizer as DoC.

Conclusion: Over two-thirds of the sample including justice-involved participants exhibited low AOD-hospitalisation trajectory. Long-term program effect was not evident for one-thirds, particularly for Aboriginal Australians, with greater psychological distress, females, opioids and cannabis/hallucinogens/tranquiliser as DoC, highlighting the importance of identifying high-risk groups, providing tailored integrated interventions and longer continuing-care.

5.3 Introduction

Alcohol and other drug (AOD) use among young people (10-24 years) remains higher than among older people (United Nations Office on Drugs and Crime, 2018). Among the 15-24 age group in Australia, alcohol and illicit drug use are the leading causes of the total burden of disease in males and the second and third leading causes for females (Australian Institute of Health and Welfare, 2019). The crude rates of drug-related hospitalisations for young people in Australia have increased since 1999-2000, with the 20-29 age group consistently having the highest rate during this period (466/100,000 people in 2018-19) accounting for the greatest percentage of drug-related hospitalisations (28%) for this age-group and 12% for the 10-19 age group in 2018-19 (Man, 2021).

Adolescence is a developmental time when both AOD-use and mental health problems can first co-occur. AOD use among some subgroups of young people, such as those with co-occurring mental health issues, places them at high risk of harm and carries substantial risk into adulthood with multiple adverse and intersecting outcomes including continued AOD use (Chassin et al., 2004; Chen & Jacobson, 2012; Evans, 2015), hospitalisations, suicidal behaviour, and deaths (Bista et al., 2021; Hodgins et al., 2009; Larm et al., 2008; Wetherill & Tapert, 2013; Whitten et al., 2022). Substance dependence is considered as a chronically relapsing condition for young people (McLellan et al., 2000; Witkiewitz & Marlatt, 2004), with a high incidence of relapse among treatment-seeking young people mostly commonly in the year following treatment (Brown et al., 2001; Cornelius et al., 2003; Ramo & Brown, 2008; Witkiewitz & Marlatt, 2004). Several risk factors, such as comorbid psychiatric conditions, low socioeconomic status, lack of family and social supports, are found to be among the most important predictors of relapse following treatment (Hser, Huang, et al., 2007; Hser, Longshore, et al., 2007; Weisner et al., 2003). Treatment retention or longer time in treatment have been shown to predict more positive outcomes including significantly decreased relapse rates in the

first year following treatment (Hser et al., 2001; Jainchill et al., 2000). However, there is a dearth of long-term (>5 years) outcome studies. Existing evidence on long-term outcomes suggests that positive effects erode over time (Edelen et al., 2010). A more recent study in Australia however suggests that staying in treatment for 30 days or more may decrease hospitalisations for a range of conditions up to 15 years post discharge (Whitten et al., 2022).

Research examining developmental patterns of AOD-use among young people after attending an AOD-program in a range of settings (e.g., outpatient, inpatient, residential) has pointed to the existence of different subgroups within the referred population with distinct developmental trajectory patterns of AOD-use over time - some groups experience positive treatment effects (e.g., abstinent or reduction in use) which are largely maintained whereas for others problematic AOD-use and associated adverse consequences continue into their adulthood (Anderson et al., 2010; Campbell et al., 2016; Chung et al., 2008; Godley et al., 2004). Some studies from this emerging body of research show a typical developmental pattern of AOD-use among young people such that AOD-use increases during adolescence and reaches its peak in middle to late adolescence or in their early to mid-20s, and then decline thereafter (Chassin et al., 2004; Chassin et al., 2013; Chen & Jacobson, 2012; Winters & Lee, 2008).

Empirical studies on developmental patterns have examined trajectories of a variety of substance use behaviours from adolescence into emerging adulthood, including alcohol use (Orlando et al., 2005; Skogen et al., 2016), marijuana use (Brook et al., 2011; Campbell et al., 2016; Homel et al., 2014; Windle & Wiesner, 2004), other illegal drug use (Dong et al., 2019; Roettger et al., 2011), and alcohol/drug dependence (Anderson et al., 2010; Chassin et al., 2004; Chung et al., 2004; Chung et al., 2008; Lee et al., 2010). While the number and shape of trajectories vary across samples, substance types and outcomes measured, studies typically identify two to six trajectories of substance use, such as chronic-high, increasing, decreasing or consistently low/abstainers. However, only a few studies have investigated AOD-use trajectories among those referred to AOD treatment programs. The studies identified provide evidence on diverse patterns of change and heterogeneity in the treatment responses in the longer-term (e.g., Anderson et al., 2010; Campbell et al., 2016; Chung et al., 2008; Hser, Longshore, et al., 2007; Winters et al., 2007). However, to our knowledge, there is no evidence on the effectiveness of residential AOD programs on the long-term AOD-use trajectories of referred young people including subsequent AOD-related hospitalisations.

The current study investigates long-term trajectory patterns of AOD-hospitalisations, i.e., a consequential outcome of different AOD-use patterns, of adolescents referred to residential AOD-program [Therapeutic Community (TC)] using linked hospital administration data up to 16 years

post-program. The specific study aims are to: (1) estimate overall AOD-hospitalisation rates of the cohort, (2) identify distinctive trajectories of AOD-hospitalisations post-referral/program, and (3) examine association of baseline pre-treatment individual and program variables associated with identified trajectory groups.

5.4 Methods

5.4.1 Study design and participants

This is a retrospective cohort study of young people (13-18 years) who were referred to a residential TC program called PALM (Program for Adolescent Life Management) for problematic AOD-use in New South Wales (NSW) and the Australian Capital Territory (ACT), Australia from 2001 to 2016 (N=3639). PALM, a modified therapeutic community (TC) program in a residential setting, provides care and support for up to three months and continuing care for up to three years. Further details of the program have been published elsewhere (Foster et al., 2010; Nathan et al., 2016). Participants are referred to PALM by the youth justice system/court, police, case workers and clinicians or by family or self-referral and assessed by expert staff for their program eligibility using the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) criteria for substance abuse/dependence over the past 12 months.

PALM client data were linked to admitted patient hospital records from all public and private hospitals in NSW and ACT including records on admissions and separations dates, and primary and secondary disease diagnosis codes using the 10th revision of the International Classification of Disease-Australian Modification (ICD-10-AM). A third-party data linkage service was used to ensure only de-identified data were provided to the research team.

This study included 3529 participants out of 3639 PALM clients (73% males, 43% identifying as Aboriginal and/or Torres Strait Islander, and median age of 16.8 years at referral). Exclusion criteria included: assessment date (or admission date if assessment date was missing) not within the study period (1 January 2001- 31 December 2016); if not aged 13-18 years; and if both assessment and admission dates were missing. Among 110 participants excluded, 74 had assessment dates outside the study period, 31 met at least one of the other exclusion criteria, and an additional five had data entry errors in the hospitalisation records. The follow-up of AOD-hospitalisations of the included sample began from the residential program exit date (or assessment date if not enrolled) until 31 December 2016.

5.4.2 Measures

Outcome variable: AOD-related hospital admissions

The outcome variable was the number of AOD-hospitalisations, measured at every 12-month period from the exit date from the residential program (or assessment date if not enrolled) until 31 December 2016 or death if occurred before this date, allowing up to 16 years of follow-up data. AOD-hospitalisations, defined as the hospital admissions with principal and/or secondary ICD-10-AM diagnosis codes on alcohol and/or drug use, were identified from the linked hospital admission data. The ICD-10 codes for AOD-hospitalisations are presented in Supplementary Appendix 1 (Table S1).

Exposure variable

The treatment program variable was measured by the length (days) of the program received before AOD-hospitalisation follow-up began, and categorised in three groups as: (a) 'days>30', who stayed in program over 30 days and up to three months (n= 1414; 40.1%), (b) 'days≤30', who stayed four to 30 days (n=877; 24.9%), and (c) 'non-attend', who were referred and assessed, but did not attend the program or attended only up to 3 days (0-3 days; n=1238; 35.1%), which was the comparison group for the analysis. Among the non-attend group, 16% attended the program for 1-3 days, and the rest 19% did not attend the program (0 days). Although detailed and consistent data were not available on reasons for not-attending the program, the recorded reasons often included: eligible but being refused bail, or eligible but did not attend due to loss of interest, or assessed as not being eligible either due to higher severity of the problems or not meeting DSM-IV criteria (Dixson et al., 2018; Nathan et al., 2020).

Pre-program covariates

The covariates or factors known to be associated with program engagement and retention which may influence AOD-hospitalisation outcomes used for this study included: age at referral; sex (assigned at birth: female/male); identifying as Aboriginal and/or Torres Strait Islander Australians [herein referred to as 'Aboriginal Australians' as the term recommended by Aboriginal Health and Medical Research Council for NSW (Aboriginal Health and Medical Research Council, 2015)] (categorised as: Aboriginal Australians/non-Aboriginal); justice-involved i.e., pre-program involvement in youth criminal justice system including justice department, court, or police (categorised as: justice-involved/non-justice-involved); mental health problems measured by Global Severity Index (GSI) T-score (categorised as: GSI<63/GSI ≥63) using 53 items from the Brief Symptom

Inventory (BSI) to calculate GSI scores and GSI T-score of 63 as the cut-off score for the clinically significant condition (Derogatis, 1993); DSM-IV substance dependence score (score≤5/score>5); and principal drug of concern (DoC) at referral (4 categories: opioids, cannabis/hallucinogens/tranquilisers, alcohol, and amphetamines/ERD/cocaine/inhalants). The descriptions of these covariates are provided in Supplementary Appendix 2.

5.5 Statistical analysis

Data analysis proceeded in 3-stages: first, estimation of overall crude and adjusted rates of AOD-hospitalisations; second, identifying latent trajectory classes of AOD-hospitalisations using growth mixture model (GMM); and third, determining predictors of identified trajectory classes using multinomial logistic regressions.

Overall AOD-hospitalisation rates

For study aim 1, we estimated crude rates of AOD-hospitalisations and corresponding rate ratios (RR) [95% confidence intervals (CI)] by various characteristics. The total person-years for each participant was calculated using the person's time in the study starting from the first assessment date for the PALM program (or the first PALM admission date if assessment date was missing) until 31 December 2016 or death, allowing up to 16 years of follow-ups. We also examined adjusted incidence rates and rate ratios (IRR) for overall AOD-hospitalisations, adjusted for age at referral, sex, Aboriginal Australian identity, PALM-program groups, and person-years, using negative binomial regression. We used SAS and R to perform these analyses.

Trajectory analysis using growth mixture model (GMM)

For the second study aim, unconditional growth mixture model (GMM) using manual three-step BCH method was performed using Mplus (version 8.6) to identify distinct longitudinal AOD-hospitalisation trajectories (latent classes) by avoiding the influence of covariates on those trajectories (Asparouhov & Muthén, 2014, 2021). For GMM, we used a sub-sample (n=3346) from the PALM data (n=3529) who exited residential program by 31 December 2015 and followed-up until 31 December 2016, allowing at least one-year of follow-up to 10 years post-exit, instead of 16 years, to minimise the missingness due to study design and in turn to prevent non-convergence of the GMM. Five time-points (follow-ups) were used for GMM, each time representing every 2-years of follow-ups, due to sparse yearly count data.

The optimal class solution of GMM was identified after performing one- to four-class unconditional quadratic models. Counts of AOD-hospitalisations were modelled using negative binomial

distribution. Missing data in AOD-hospitalisations due to a study design was considered a missing at random (MAR) and addressed by using the full information maximum likelihood (FIML) with robust standard errors estimation approach (Enders, 2010). The GMMs specified with varying class numbers were compared and the optimal class solution was selected using lower absolute values of information criteria indices: Akaike information criterion (AIC), Bayesian information criterion (BIC), and sample-adjusted BIC, including other criteria: significant Lo-Mendell-Rubin likelihood ratio test (LRT) P-value, classification quality (average posterior probability >0.7 indicating good model fit and precision), and substantive importance of the trajectory groups (van der Nest et al., 2020). More information on model identification and selection are presented in Supplementary Appendix 3 (Model Selection).

Predictors of identified trajectory classes

For the third study aim, after identifying the optimal unconditional GMM, a predictive model was specified which included the baseline variables as predictors of the identified trajectory classes. Using multinomial logistic regression, all predictors were entered in the model simultaneously, thus the estimates for the predictors were controlling for the effects of other predictors. Missing data in covariates were imputed following the multiple imputation approach provided for BCH method (Asparouhov & Muthén, 2021). Odds ratios (ORs) and 95% confidence intervals (CIs) were reported. See Supplementary Appendix 3 (sub-sections: Multinomial logistic regression and Missing data) for more descriptions on multinomial logistic regression and multiple imputation approach used.

5.6 Results

5.6.1 Study cohort baseline characteristics

Table 4 presents overall sample characteristics by sex. Over two-thirds (68%, n=1980) of the respondents (n=2897) had high substance dependence scores (DSM-IV scores>5), with a larger proportion among females than among males (76% vs 66%, P<.0001) showing greater severity of dependence. The common drug of concern (DoC) requiring treatment were alcohol, cannabis, amphetamines, ecstasy/related drugs (ERD), and opioids. The majority (91%) of the respondents, with a larger proportion among females than among males (94% vs 90%; P= 0.0178), reported poly-drug use. Males were more likely to involve with youth justice system/court/police than females (57% vs 34%, P<0.0001). A quarter (26%, n=682) of BSI respondents (n=2624) reported clinical psychological distress levels (GSI T-score ≥63), with a larger proportion of females than males reporting clinical distress level (47% vs 18%; P<0.0001). Around a third of the cohort reported ever attempting suicide (30%, n=1074) or self-harming (32%, n=1117), a half (50%, n=1774) experienced

physical assault by someone known to them and 15% (n=545) experienced sexual assault by someone known to them. Larger proportions among females than among males had these suicide, self-harm, and trauma experiences.

Table 4: Pre-program characteristics of cohort by gender, 2001-2016 (N=3529)

Characteristics	Total (N=3529)	Male (n=2567, 73%)	Female (n=962, 27%)	Chi-square p-values
Aboriginal identity				
Aboriginal Australians	1499 (43%)	1164 (45%)	335 (35%)	<.0001
Non-Aboriginal	2030 (57%)	1403 (55%)	627 (65%)	
Program-attend groups				
Non-attend (0-3 days)	1238 (35%)	903 (35%)	335 (35%)	
Days ≤30 (4-30 days)	877 (25%)	640 (25%)	237 (25%)	0.9402
Days >30 (>30 days)	1414 (40%)	1024 (40%)	390 (41%)	
Age at referral (years)				
13-14	324 (9%)	198 (8%)	126 (13%)	
15-16	1734 (49%)	1229 (48%)	505 (52%)	<.0001
17-18	1471 (42%)	1140 (44%)	331 (35%)	
DSM-IV Substance Dependence Score (3-7) (respondents: n=2897) [a]				
Score ≤5	917 (32%)	728 (35%)	189 (24%)	<.0001
Score >5	1980 (68%)	1382 (66%)	598 (76%)	
Principal drug of concern at assessment (respondents: n=2696) [b]				
Alcohol	1000 (37%)	747 (38%)	253 (34%)	
Cannabis	563 (21%)	432 (22%)	131 (18%)	
Amphetamines	528 (20%)	361 (18%)	167 (23%)	
Ecstasy and related drugs (ERD)	373 (14%)	261 (13%)	112 (15%)	
Opioids [c]	132 (5%)	79 (4%)	53 (7%)	
Cocaine	29 (1%)	21 (1%)	8 (1%)	
Other [d]	71 (3%)	54 (3%)	17 (2%)	
Poly-drug use - last 3 months at assessment (respondents: n=1946) [a]				
Yes	1776 (91%)	1281 (90%)	495 (94%)	0.0178
No	170 (9%)	137 (10%)	33 (6%)	
Involvement in youth justice or related (respondents: n=2908) [a]				
No	1432 (49%)	907 (43%)	525 (66%)	<.0001
Yes	1476 (51%)	1206 (57%)	270 (34%)	
BSI Global Severity Index (respondents: n=2624) [a]				
GSI T-score <63	1942 (74%)	1556 (82%)	386 (53%)	<.0001
GSI T-score ≥63	682 (26%)	336 (18%)	346 (47%)	
Mental health issues at assessment [b]				
Attempted, end life- ever	1074 (30%)	611 (24%)	463 (48%)	
Attempted, end life- in last 3 months	393 (11%)	219 (9%)	174 (18%)	
Self-harmed - ever	1117 (32%)	647 (25%)	470 (49%)	
Self-harmed- in last 3 months	388 (11%)	214 (8%)	174 (18%)	
Trauma - experienced/witnessed [b]				
Physical assault-known	1774 (50%)	1209 (47%)	565 (59%)	
Physical assault-stranger	1305 (37%)	1008 (39%)	297 (31%)	
Sexual assault-known	545 (15%)	192 (7%)	353 (37%)	
Sexual assault-stranger	278 (8%)	94 (4%)	184 (19%)	
Verbal abuse	1212 (34%)	759 (30%)	453 (47%)	

[a] Numbers and percentages are presented as per available data on this variable.

[b] Percentage in each category was calculated out of the total cohort sample (by sex, and overall), and the percentages are not mutually exclusive and therefore do not add to total (100%). Due to being not mutually exclusive, Chi-squared tests were not performed for these characteristics.

[c] 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).

[d] Other includes inhalants, hallucinogens, tranquiliser, and other unspecified, which were combined due to small values (<5) in some cells.

5.6.2 Crude and adjusted rates and rate ratios (RRs) of AOD-hospitalisations

Table 5 presents crude and adjusted (for sex, Aboriginal identity, age at referral, and program-attend groups) AOD-hospitalisation rates [95% CI] post-program. For up to 16 years of follow-up (28782 person-years) with a median follow-up of 8.11 years, a total of 5415 AOD-hospitalisations occurred in the 3529 participants, resulting in a hospitalisation crude rate of 188 per 1000 person-years [183.16-193.22]. Both crude and adjusted AOD-hospitalisation rates were higher for females (71% higher) than males (RR: 1.71 [1.62-1.81]; adjusted RR: 1.84 [1.59-2.12]), for Aboriginal Australians than non-Indigenous young people (RR: 1.31 [1.06-1.18]; adjusted RR: 1.22 [1.07-1.40]), older participants (17-18 years) than 13-14 years group (RR: 1.25 [1.13-1.38]; adjusted RR: 1.16 [1.09-1.23]), and both program-attend groups (days≤ 30 and days>30), with 35% higher for days≤30 group (RR: 1.35 [1.26-1.45]; adjusted RR: 1.32 [1.11-1.57]) and 23% higher for days>30 group (RR: 1.23 [1.15-1.31]; adjusted RR: 1.22 [1.05-1.42]) than the non-attend group. However, there was no evidence of significant difference in the AOD-hospitalisation rates between days ≤30 and days >30 program groups. AOD-hospitalisation crude rates increased with the severity of the pre-program psychological distress, with an 82% increased risk for those with higher severity (GSI≥63) than those with less severity (GSI<63) (RR: 1.82 [1.70-1.95]). However, AOD-hospitalisation rates were significantly lower for those with justice-involved compared to non-justice-involved participants (RR: 0.65 [0.61-0.70]).

Table 5: Crude and adjusted AOD-hospitalisation rates and rate ratios (RR) by demographic, program, and pre-program characteristics for the study cohort (N=3529), 2001-2016

Crude (unadjusted) AOD hospitalisation rates and rate ratios						
	Number of participants (%)	**Total counts of AOD-hospitalisations**	**Person-years**	**AOD-hospitalisation rate per 1000 person-year (95% CI)**	**Rate Ratio (RR) (95% CI)**	**P-value**
Total	3529	5415	28781.84	188.12 (183.2-193.2)		
Gender						
Male	2567 (73%)	3288	20883.36	157.45 (152.1-162.9)	*1.0 (reference)*	
Female	962 (27%)	2127	7898.48	269.29 (258.0-281.0)	1.71 (1.62-1.81)	<.001
Aboriginal identity						
Non-Aboriginal	2030 (58%)	2838	16977.12	167.17 (161.1-173.4)	*1.0 (reference)*	
Aboriginal Australians	1499 (42%)	2577	11804.72	218.30 (209.9-226.9)	1.31 (1.06-1.18)	<.001
Age group at referral (years)						
13-14	324 (9%)	430	2560.66	167.93 (152.4-184.6)	*1.0 (reference)*	
15-16	1734 (49%)	2437	14045.97	173.50 (166.7-180.5)	1.03 (0.93-1.14)	0.532
17-18	1471 (42%)	2548	12175.2	209.28 (201.2-217.6)	1.25 (1.13-1.38)	<.001
Program groups						
Non-attend	1238 (35%)	1644	10265.6	160.15 (152.5-168.1)	*1.0 (reference)*	
Days ≤30	877 (25%)	1453	6711.27	216.50 (205.5-227.9)	1.35 (1.26-1.45)	<.001
Days >30	1414 (40%)	2318	11804.96	196.36 (188.5-204.5)	1.23 (1.15-1.31)	<.001
Involvement in juvenile justice or police [a]	(n = 2908) [b]					
No	1432 (49%)	3156	13747.4	229.57 (221.6-237.7)	*1.0 (reference)*	
Yes	1476 (51%)	1169	7807.46	149.73 (141.3-158.6)	0.65 (0.61-0.70)	<.001
Global Severity Index (GSI) score	(n = 2624) [b]					
<63	1942 (74%)	2181	13588.48	160.50 (153.8-167.4)	*1.0 (reference)*	
≥63	682 (26%)	1435	4908.19	292.37 (277.4-307.9)	1.82 (1.70-1.95)	<.001

Adjusted AOD hospitalisation estimates and rate ratios (negative binomial regression)					
		Estimates	**SE**	**P-value**	**Rate Ratios (RR) (95% CI)**
Female	(Ref: Male)	0.6087	0.073	<.0001	1.84 (1.59-2.12)
Aboriginal Australians	(Ref: Non-Aboriginal)	0.2026	0.068	0.0027	1.22 (1.07-1.40)
Age at referral (years)		0.1443	0.032	<.0001	1.16 (1.09-1.23)
Program groups					
Days ≤30	(Ref: Non-attend)	0.2804	0.088	0.0015	1.32 (1.11-1.57)
Days >30	(Ref: Non-attend)	0.1994	0.077	0.0098	1.22 (1.05-1.42)

[a] Involvement in youth justice system or court order or police or remand.

[b] Smaller sample was used due to missing data in this variable.

5.6.3 Growth mixture model: Identifying AOD-hospitalisation trajectories (n=3346)

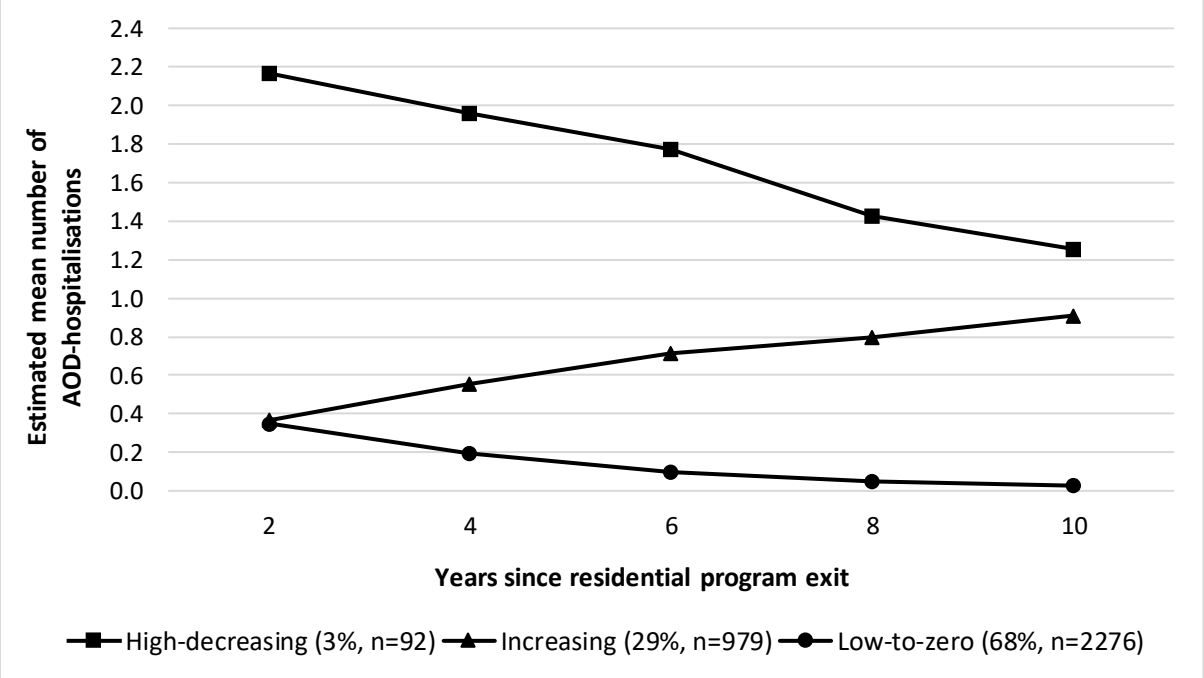
Based on the model fit indices and other selection criteria (Table 6), we selected 3-class GMM (Figure 2) as the optimal model and the classes were labelled as: *low-to-zero* class (68.0%, n = 2276), *increasing* class (29.2%, n=978), and *high-decreasing* (2.7%, n=92). Detailed model selection process is presented in Supplementary Appendix 4.

Table 6: Model fit comparison with an increasing number of trajectory classes

	Models with different number of classes			
	1	**2**	**3**	**4**
AIC	17542.6	17420.0	**17401.2**	17395.433
BIC	17579.3	17488.3	**17492.9**	17517.744
Sample-size adjusted BIC	17560.2	17453.3	**17445.2**	17454.195
LRT P-value		0.0001	**0.0001**	0.889*
Entropy		0.35	**0.534**	0.600
Averaged posterior probability of group membership per class		0.79/0.81	**0.63/0.74/0.80**	0.63/0.56/0.72/0.81
Sample size per class based on the estimated model (%)		31.6/68.4	**2.7/29.2/68.0**	2.7/3.0/23.5/70.8

*LRT computation did not terminate normally.

Figure 2: AOD-hospitalisation trajectories of young people referred to residential program from 2001 to 2015 and followed-up for 10 years post-program (n=3446)



5.6.4 Examining baseline predictors of trajectory classes using multinomial logistic regression

Table 7 presents the results of multinomial logistic regression examining predictors of trajectory groups of the 3-class model. Compared to the *low-to-zero* group, participants in the *high-decreasing* class were significantly more likely to identify as Aboriginal Australians (OR = 8.46 [2.76-25.94]), have greater psychological distress (GSI≥63) (OR = 4.53 [1.24-16.53]), and report opioids (OR = 11.33 [1.04-128.08]) and cannabis/hallucinogens/tranquilizer (OR = 4.61 [1.32-16.11]) (vs. alcohol) as their

drug of concern (DoC) at referral. There was no significant difference between odds of females and males being in this class.

Participants in the *increasing* AOD-hospitalisation group, compared to *low-to-zero*, were significantly more likely to be older at referral (OR = 1.25 [1.01-1.53]), identify as Aboriginal Australian (OR = 4.35 [2.60-7.31]), females with lower psychological distress (GSI<63) (OR = 2.54 [1.35-4.78]), or males with greater psychological distress (GSI≥63) (OR = 2.38 [1.13-5.0]). Further, those reporting opioids (OR = 19.64 [2.63-146.95]) and cannabis/hallucinogens/tranquilizers (OR = 3.64 [1.83-7.24]) as their DoC were more likely to be in this group. Those who were justice-involved (vs. non-justice-involved) in both program groups were significantly less likely to be in the *Increasing* group (OR = 0.27 [0.01-0.53] in Days ≤ 30; OR = 0.51 [0.15-0.86] in Days>30), compared to *low-to-zero* (Table 7).

Conversely, participants in the *low-to-zero* group were less likely to be older, identify as Aboriginal Australian, females, have higher psychological distress (GSI≥63), and report opioids and cannabis/hallucinogens/tranquilizers as their DoC (vs alcohol), and more likely to be justice-involved, compared with other two group (Appendix 5: Table S3). Those who reported alcohol and amphetamines/ERD/cocaine/inhalants as DoC (vs opioids) were more likely to be in *low-to-zero* group (vs *increasing* group) (Appendix 5: Table S4).

Table 7: Association of latent trajectory classes with demographic, program, program, pre-program variables, 2001-2015 (N=3446)

Predictor variables	***High-decreasing* vs. *Low-to-zero***		***Increasing* vs. *Low-to-zero***	
	OR [95% CI]	***P***	**OR [95% CI]**	***P***
Referral age (centred at 13 years)	1.50 [0.90-2.50]	0.125	**1.25 [1.01-1.53]**	**0.039**
Aboriginal identity:				
Aboriginal Australians (vs Non-Aboriginal)	**8.46 [2.76-25.94]**	**<0.001**	**4.35 [2.60-7.31]**	**<0.001**
Gender:				
Female (vs Male)	1.42 [0.44-4.60]	0.556	**2.54 [1.35-4.78]**	**0.004**
Program:				
Days≤30 (vs Non-attend)	1.92 [0.43-8.55]	0.391	1.05 [0.43-2.56]	0.92
Days>30 (vs Non-attend)	1.41 [33-6.07]	0.645	0.78 [0.34-1.78]	0.556
Justice system/police/court involved at referral:				
Justice-involved: Yes (vs No)	0.29 [0.08-1.05]	0.06	0.51 [0.19-1.37]	0.181
Global Severity Index (GSI) T-score:				
GSI≥63 (vs GSI<63)	**4.53 [1.24-16.53]**	**0.022**	**2.38 [1.13-5.0]**	**0.022**
Substance Dependence score				
score >5 (vs score ≤5)	0.81 [0.27-2.41]	0.702	1.33 [0.80-2.21]	0.271
Drug of concern (DoC) at referral				
Opioids (vs alcohol)	**11.52 [1.04-128.08]**	**0.047**	**19.64 [2.63-146.95]**	**0.004**
Cannabis/hallucinogens/tranq [a] (vs alcohol)	**4.61 [1.32-16.11]**	**0.017**	**3.64 [1.83-7.24]**	**<0.001**
Amph [a]/ERD/cocaine/inhalants [a] (vs alcohol)	0.35 [0.02-6.90]	0.49	1.30 [0.72-2.36]	0.386
Interactions of justice involvement and program [b]:				
Justice-involved*Days≤30			0.53 [0.14-2.02]	0.35
Justice-involved: Yes (vs No) in Days≤30			**0.27 [0.01-0.53]**	**0.042**
Days≤30 (vs Non-attend) in Justice-involved: yes			0.56 [0.05-1.07]	0.196
Justice-involved*Days>30			0.99 [0.31-3.19]	0.991
Justice-involved: Yes (vs No) in Days>30			**0.51 [0.15-0.86]**	**0.005**
Days>30 (vs Non-attend) in Justice-involved: Yes			0.78 [0.21-1.35]	0.489
Interaction of GSI T-score and gender [b]:				
GSI≥63*Female			0.38 [0.13-1.16]	0.89
GSI≥63 (vs GSI<63) in Females			0.92 [0.13-1.72]	0.822
Female (vs Males) in GSI≥63			0.98 [0.12-1.84]	0.936

[a] Tranq=tranquiliser; Amph=amphetamine; ERD=ecstasy related drugs

[b] These interactions were not performed for *High-decreasing* class due to its smaller class size.

5.7 Discussion

As the first longitudinal study of linked AOD-hospitalisations of young people referred to a residential program (TC) for problematic AOD-use during adolescence, this study provides evidence on post-program overall AOD-hospitalisation rates, and heterogeneity in AOD-program responses by identifying three distinct trajectories of AOD-hospitalisations into adulthood and analysing baseline predictors (pre-program and program) associated with these trajectories.

Estimated overall crude AOD-hospitalisation rates of the sample using 16 years of follow-up post-PALM showed a substantially elevated rate of approximately one in five AOD-hospitalisations per year (188/1000 person-years), compared with the national crude rate of approximately one in two-

hundred people (i.e., 466 drug-related hospitalisations/100,000 people) in the 20-29 age group (Chrzanowska et al., 2019). By examining rates for univariate characteristics, we found that the crude AOD-hospitalisation rates were higher for females, young Aboriginal Australians, those older at referral, program-attending groups (days≤ 30 and days>30 vs. non-attend group), and those with higher psychological distress (GSI≥63). Interestingly, the AOD-hospitalisation crude rates were lower for those referred by the justice system/court/police vs non-justice-involved. These findings of different crude rates of AOD-hospitalisations among different subgroups of participants indicate that there is a heterogeneity in the AOD-program responses in the sample. We applied growth mixture modelling (GMM) to confirm this assertion of existence of different subgroups showing different treatment responses with different outcomes in this study.

Using GMM, we identified three distinct and data-driven AOD-hospitalisation trajectories from adolescence through to early adulthood, showing heterogenous post-program/referral AOD use by these three distinct subgroups of study participants. During the first two years post-program/referral, a vast majority of the sample (97%) belonging to two trajectory groups: *low-to-zero* and *increasing* demonstrated very low average AOD-hospitalisations, indicating an early positive response or low level of OAD use. This finding, although the AOD-use was not directly studied in the current study, is consistent with the previous finding of early lower AOD-use patterns post-treatment among most of the sample (Anderson et al., 2010; Brown et al., 2001). After two years in the current study, over two thirds of the participants (68%) continued demonstrating a sustained low and gradually desisted level of AOD-hospitalisations (*low-to-zero* group) during their late adolescence through to adulthood. Although the explanation for this positive result is unclear and this study is not measuring the AOD use directly, this positive result of low AOD-hospitalisations for most of the participants could be possibly reflecting sustained AOD-program effects, which was relevant particularly for those who had attended the program. Most of the participants (65% from the two program-attending groups: $\text{days} \leq 30$ and $\text{days} > 30$, and 16% from the non-attending groups who attended the AOD program for 1-3 days) attended the PALM program. Additionally, some protective factors, such as individual personality (e.g., maturity, resilience, emotional control), family and peer support, and environmental factors (e.g., socioeconomic status, and neighbourhood) may have served to buffer the risk factors for AOD use during adolescence and as they transition into-young adulthood and adulthood (Brown & Ramo, 2006).

However, the positive trends in AOD-hospitalisations were not evident for one third (32%) of the sample (*increasing* group) with the AOD-hospitalisation trajectory consistently increasing after two years post-program into adulthood, particularly from late adolescence and young adulthood through

to adulthood. This finding is consistent with other research on post inpatient treatment AOD-trajectories showing the acceleration of AOD-use during late adolescence and emerging adulthood (Anderson et al., 2010). This finding of increasing trajectory in the current study highlights the importance of identifying at-risk group at program entry to provide tailored program to maximise program benefit and ensuring effective continuing-care to sustain the initial positive effects over time. The third trajectory group, *high-decreasing*, although small in group size (3%), has captured a unique pattern of high AOD-hospitalisations due to persistent high AOD-use pattern of the class members, indicating that this group was severely AOD-dependent. Similar high AOD-use patterns among smaller group of participants post-treatment have also been found in other studies of different treatment settings ((Anderson et al., 2010; Chung et al., 2008). For example, Anderson et al. (2010) has found 6% of the sample exhibiting very high and chronic AOD-use post inpatient treatment. In the current study, however, very high initial AOD-hospitalisation rates decreasing gradually over time seen in *high-decreasing* group indicates that this group may have received some form of treatment services over time, such as, continuing-care or additional AOD-programs or mental health services, that may have helped them to lower the initial high level of AOD-use patterns.

Further analysis revealed that baseline individual and contextual factors differentiated these AOD-hospitalisation trajectories. Our results showed that participants in the low AOD-hospitalisations group (*low-to-zero*) were more likely to have lower mental health problem scores, be male, younger at referral, and non-Aboriginal, have alcohol and meth/amphetamines/ERD as DoC at referral (vs opioids and cannabis), compared to the other trajectory groups. We found an interesting finding from this analysis that the justice-involved participants were significantly more likely to be in the *low-to zero* trajectory group, compared to *increasing* group. This finding was consistent with the earlier results from the crude rates analysis in the current study showing low AOD-hospitalisation crude rates for the justice-involved participants. Despite the evidence on the relationship between crime and greater AOD-use (Australian Institute of Health and Welfare, 2018c; Bennett et al., 2008), we found that the justice-involved participants, particularly those who were justice-involved and stayed in the program (days>30 or days≤30), were more likely to demonstrate low-AOD hospitalisation trajectory (i.e., *low-to-zero* group), compared to *increasing* group. The explanation for this association is unclear and needs further research. Although length of treatment exposure to program (days>30 or days≤30 vs non-attend) was not independently associated with any trajectory class, the finding of those who attended the program (days>30 or days≤30 vs non-attend) among justice-involved participants showing positive outcome indicates that the residential (TC) AOD-program is effective for the justice system referred participants and, therefore, broadly support

utilisation of residential AOD-program for this sub-group. Around half (51%) of the current sample was referred by the justice system (justice department or court or police). The justice system refers young people to AOD-program with the aim to prevent repeated direct (due to illicit drug use) or indirect (licit or illicit drug use related offences, e.g., theft and acts intended to cause injury) contact with the justice system and to improve outcomes of young people (Australian Institute of Health and Welfare, 2018c; Green et al., 2016). Consistent to our findings, prior evidence also show marked reductions in AOD-use and involvement in crime after an AOD-program for young people referred by justice system (Edelen et al., 2010; Farabee et al., 2001; Fletcher & Grella, 2001; Gossop et al., 2005; Whitten et al., 2022).

In contrast, both higher AOD-hospitalisation trajectories (*increasing* and *high-decreasing*), compared to *low-to-zero* group, were strongly predicted by greater psychological distress (GSI≥63), identifying as Aboriginal Australians, and reporting opioids and Cannabis/hallucinogens/tranquiliser as DoC (vs alcohol and meth/amphetamines/ERD/cocaine/inhalants). Being older at referral uniquely predicted the *increasing* class. We did not find evidence for pre-treatment substance dependency (scores>5 vs scores≤5) significantly predicting trajectory classes, however, odds ratios indicated that those with greater substance dependence had higher odds of being in *increasing* group than the other two groups. Our findings that those with greater psychological distress demonstrating higher AOD-hospitalisation trajectories support prior evidence which show a strong association between comorbid mental health, in particular major depression and ongoing problematic AOD-use (National Institute on Drug Abuse, 2018). People with AOD problems and comorbid mental health issues have been previously found to be at very high risk for continued AOD dependency and mental health problems into adulthood (Burns et al., 2005; Degenhardt et al., 2018; Drake et al., 2005; Grella et al., 2001; National Institute on Drug Abuse, 2018) including increased risk of self-harm and suicide (Mills et al., 2019).

This situation of increased risk from co-occurring mental health issues and AOD-use is particularly alarming for young Aboriginal Australians (Australian Institute of Health and Welfare, 2018a; Gray et al., 2018), supporting our finding that Aboriginal Australians were more likely to have higher AOD-hospitalisation trajectories, in which participants had greater pre-program psychological distress (GSI≥63). In the current study, 42% of the participants were young Aboriginal Australians, and over a third (>34%) of Aboriginal Australian participants had pre-existing experiences of attempting suicide and/or self-harm. National data shows Aboriginal Australians experience higher rates of mental health issues than non-Indigenous people, with 2 in 5 young Aboriginal Australians aged 15-24 reporting long-term mental health issues, mainly anxiety disorders, depressive disorders,

behavioural or emotional problems and harmful drugs or alcohol use or dependence (Australian Institute of Health and Welfare, 2018a). Self-harm and suicide rates among young Aboriginal Australians (<25 years) are also among the highest in the world (Dickson et al., 2019; Dudgeon et al., 2016; Nathan et al., 2020). Drug- and alcohol-related hospitalisations among Aboriginal Australians are 3 and 4 times respectively higher than that for non-Aboriginal people (Australian Institute of Health and Welfare, 2020). It is well-established evidence that greater mental health problems and associated AOD-use or -dependence among young Aboriginal Australians are associated with the cumulative effects of intergenerational trauma from colonisation and the Stolen Generations, racism, social exclusion, inadequate access to health services including a lack of well-funded community-controlled services, and the result of other social determinants including unemployment, incarceration and homelessness (Australian Institute of Health and Welfare, 2018a, 2020; Calma et al., 2017; Gray et al., 2018; Nathan et al., 2020; Wilkes et al., 2010; Williamson et al., 2018). Our findings highlight the importance of tailored and culturally safe AOD-programs designed specifically for and with young Aboriginal Australians, as suggested by previous study (Nathan et al., 2020) addressing their life complexities and comorbidities and also drawing on cultural and community strengths to support them in programs and back in the community. Offering culturally safe model of care with respectful collaboration, and self-determination by local community Elders and leaders is required, as is the right of Indigenous people worldwide (United Nations, 2008). Continuing care that supports these young people, families and their communities is also urgently required with an appropriately skilled Aboriginal workforce and Aboriginal community-controlled organisations as partners or program leaders (Nathan et al., 2020). Hospitalisations are an important opportunity to improve access to other services, however earlier intervention, integrated care and prevention are overwhelmingly preferable to presentations at hospital for AOD issues (Carson et al., 2020; Conroy & Williams, 2017; Ridoutt et al., 2019).

In the current study, females were more likely to be in the *increasing* group. However, interaction of sex and mental health scores showed that females, although having low to moderate mental distress (GSI<63), and males with greater mental health problems (GSI≥63) were at greater risk of being in the *Increasing* group, compared to *low-to-zero* group. The explanation for the finding that more females, despite having lower mental distress, showing an increasing AOD-hospitalisation trajectory could be due to a larger proportion of females being poly-drug users and having greater substance use dependence (score >5) at referral. This is consistent with prior studies that show females are more likely to use substances at greater levels and more harmful way than that of males, causing elevated hospitalisations and mortality (Bista et al., 2021; Degenhardt et al., 2011; Lindblad et al., 2016; Mitchell et al., 2016) including suicides (Pompili et al., 2012; Schneider, 2009). Young women

attending AOD-programs largely experience higher rates of psychosocial problems including mental health problems, trauma, sexual abuse, self-injury, suicide attempts, and homelessness, than male counterparts (Bista et al., 2021; Dixson et al., 2018; Mitchell et al., 2016). Meeting the specific needs of females in residential program is under-studied and the relationship of their drug use to prior trauma as suggested by previous research (Dixson et al., 2018). These studies indicate the need for a more trauma-informed and targeted approach; however, further research is required

Furthermore, our findings of association of pre-treatment opioids and cannabis use as DoC (vs. alcohol) with both higher AOD-hospitalisation trajectories (*increasing* and *high-decreasing*), compared with *low-to-zero*, agree with prior evidence that young people with greater mental health problems including major depression and anxiety disorder exhibit using opioids (mostly heroin), cannabis, sedatives/hypnotics or poly-drugs (Albertella & Norberg, 2012; Bartu et al., 2004; Burdzovic et al., 2015; White et al., 2004). Both higher trajectories of AOD-hospitalisations in this study were associated with greater mental health scores (GSI≥63). Previous research indicates that post-treatment relapse among adolescents generally follow the pre-treatment patterns of drug use (Cornelius et al., 2003; Maisto et al., 2001; Marel et al., 2019). Although an analysis of drugs types in hospitalisation trajectories was not an aim of the current study, national survey shows that those with mental disorders are common among people hospitalised for opioid-related harms, most notably for opioid-related poisonings and opioid use disorders (Australian Institute of Health and Welfare, 2018b). Similarly, heavy and daily cannabis use in young people is strongly associated with pre-existing mental health problems (Lawrence et al., 2015; Marel et al., 2019), and persistent adolescent cannabis use co-occurring with mental health problems is strong predictive of problematic cannabis use at young adulthood and may require hospitalisations (Marel et al., 2019; Reichelt et al., 2019; Swift et al., 2008). Our findings supported by prior evidence suggest for better screening and tailored and integrated program including continuing care for those at greater risk of continued AOD-use and greater mental health conditions through to adulthood.

Implications

Our findings point to a strong support for residential programs for those referred by the justice system, however, further research is recommended to confirm the support of residential AOD program for justice-involved adolescents. The program effects were not evident in the modelling or AOD-hospitalisation outcomes were worsened for those with greater psychological distress and for young Aboriginal Australians. These findings highlight the importance of tailoring treatment for different groups including females, young Aboriginal Australians and those with greater psychological distress who are at greater risk of increased AOD-hospitalisations post-program

through to young adulthood and adulthood. However, further research is required to understand young people's experiences in AOD-programs and how programs and continuing care may need to be re-designed and enhanced to provide needed supports to maximise positive outcomes for all those referred to residential programs.

Limitations

The limitations of this study include: firstly, due to beyond the scope of this study, we did not investigate whether the participants with no AOD-hospitalisations during the study period had been involved in AOD-use post-program although not hospitalised, which could restrict the generalisability of our findings in relation to the effectiveness of residential program. Second, self-report data for pre-program mental health conditions (BSI) was subject to bias and errors of recall. Third, although entropy is not a measure of model fit, with the reported entropy value (<0.7), classification bias may have occurred. However, averaged posterior probability of group membership value being >0.7 in two larger trajectory classes (*low-to-zero* and *increasing*) indicates greater classification precision. Fourth, the proportion of membership in the *High-decreasing* trajectory was relatively small (2.7%), therefore this group was not powered to use the interaction terms in the multinomial logistic regression.

5.8 Conclusion

Over two-thirds of the cohort including those referred by the justice system were in the low or no AOD-hospitalisation trajectory post-program. However, the program effect or positive outcome was not observed for one-third of the cohort, particularly for those with greater mental health issues, females, and young Aboriginal Australians, who showed high or increasing AOD-hospitalisation trajectories. These findings highlight the importance of early screening to identify these high-risk groups, and targeted, age, gender appropriate and culturally safe integrated interventions including longer and customised continuing care particularly for those with co-occurring mental health issues. Further research is needed to evaluate the extent to which one AOD-program can address comorbidity and the range of needs among the diversity of young people referred.

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CHAPTER 6: Trajectories of mental health related hospitalisations of adolescents referred to a residential program for drug and alcohol use problems: A longitudinal data linkage study

6.1. Preamble

The study in the previous chapter investigated the long-term AOD related morbidity of the cohort following the residential program. The study in this chapter investigates mental health morbidity of adolescents referred to PALM residential program using linked data on mental health related hospitalisations (MH-hospitalisations) following up to 16 years post-PALM. More specifically, this study estimates crude MH-hospitalisation rates, identifies distinct MH-hospitalisation trajectories over time and their predictors. This study will help service providers identifying high-risk subgroups and understanding their characteristics at early screening and tailor the AOD programs addressing their comorbidities and complex treatment needs.

6.2. Abstract

Background: Long-term mental health outcomes of adolescents referred to residential AOD-programs are less known. We investigated long-term post-program mental health hospitalisation (MH-hospitalisation) trajectory patterns and associated baseline risk-factors.

Methods: Adolescents (13–18 years) referred to residential program (n=3529) were followed up to 16 years post-program using hospitalisation data-linkage. MH-hospitalisation crude rates were estimated. MH-hospitalisation trajectories were identified using growth mixture modelling (GMM). Risk-factors associated with trajectories were examined using multinomial logistic regression.

Results: The sample (73% males; 43% Aboriginal Australians; median referral-age=16.8 years; median follow-up=8.11 years) had 5397 MH-hospitalisations. Overall MH-hospitalisation crude rate was 188/1000 person-years [95% CI: 183.0-192.58]. Crude rates were higher for females, older-group, program-attending groups (days≤30, days>30), those with greater psychological distress (GSI≥63), and lower for justice-involved participants. GMM identified three MH-hospitalisation trajectories; a quarter of the sample exhibited poorer outcomes (*chronic-high* (7%) and *increasing* (21%) trajectories) and Aboriginal Australians were more likely to have this outcome. Justice-involved participants demonstrated low MH-hospitalisations. Predictors of *chronic-high* trajectory (vs *low-to-zero*): Aboriginal Australians (OR=3.04 [1.68-5.53]), those with GSI≥63 (OR=2.33 [1.14-4.75]), justice-involved (OR=0.28 [0.13-0.58]), cannabis/hallucinogens/tranquilizer as DoC (OR=2.83

[1.27-6.32]), unstable living (OR=2.46 [1.20-4.50]). Risk-factors predicting *increasing* trajectory (vs *low-to-zero*): older-age (OR=1.48 [1.08-2.03]), Aboriginal Australians (OR=3.03 [1.56-5.86]), justice-involved (OR=0.16 [0.07-0.39]).

Conclusion: Around three-quarters of the sample including justice-involved participants exhibited low MH-hospitalisation trajectory. Long-term program effect was not evident for over a quarter, particularly for Aboriginal Australians, with greater psychological distress, cannabis/hallucinogens/tranquiliser as DoC and unstable living, highlighting the importance of identifying high-risk groups at screening, providing tailored integrated interventions and longer continuing-care.

6.3 Introduction

Mental health and substance use disorders are among the most common health problems affecting adolescents, with prevalence of 20% (11-17 years) for high or very high levels of psychological distress and 16% (14-19 years) for illicit drug use in Australian population-based surveys (Australian Institute of Health and Welfare, 2021, 2023). Adolescence is a developmental time when not only the initiation of alcohol and other drug (AOD) use or the onset of mental health problems typically occur, but also the first co-occurrence of both substance use disorder and psychiatric conditions is common (Esmaeelzadeh et al., 2018; Hawkins, 2009; National Institute on Drug Abuse, 2018b). While there is no evidence of clear direction of causal relationship between onset of mental health problems and onset of AOD use among adolescents, the limited literature on prospective studies link pre-existing mental health problems among adolescents to early initiation of AOD use and likelihood of later problematic use or dependence (Elkins et al., 2007; King et al., 2004; Skogen et al., 2016; Strandheim et al., 2011); conversely, the early initiation of AOD-use has been linked to long-term poorer behavioural and mental health problems (Arseneault et al., 2002; Brown et al., 2000; Loxley et al., 2004; Sarala et al., 2020; Weinberg et al., 1998; Wetherill & Tapert, 2013). Some suggest that having a psychiatric disorder in adolescence is a potent risk factor for having a psychiatric disorder in adulthood (Castagnini et al., 2016; Copeland et al., 2013). Furthermore, evidence suggests that, compared with adolescents with AOD-use problems alone, adolescents with substance use and comorbid psychiatric disorders are more likely to be at higher risk of harm including carrying substantial and intersecting risks into adulthood including greater risk of relapse, and continued substance use or substance dependence (Bender et al., 2006; Brewer et al., 2017; Deas, 2006; Hawkins, 2009), involvement with criminal justice system (Couwenbergh et al., 2006; Whitten et al., 2022), hospitalisations, suicidal behaviour, and death (Bista et al., 2021; Hodgins et al., 2009; Larm et

al., 2008). Additionally, adolescents with comorbid AOD-use and psychiatric diagnoses are less likely to respond to treatment (Ramchand et al., 2014; Shane et al., 2003).

Prevalence studies show that AOD-use disorder and comorbid mental health conditions are higher among adolescents seeking AOD-treatment, with evidence that 60-90% of adolescents in community-based AOD-treatment also meet diagnostic criteria for at least one, and often more than one mental health condition (Brewer et al., 2017; Chan et al., 2008; Couwenbergh et al., 2006; Grella et al., 2001; Hser et al., 2001; Rowe et al., 2004). Depression, anxiety, conduct disorder (CD), affective disorder (AD), and attention-deficit hyperactivity disorder (ADHD) are the most prevalent comorbid mental health conditions among the AOD treatment-seeking adolescents (Armstrong & Costello, 2002; Brown et al., 1996; Chan et al., 2008; Crowley et al., 1998; Grella, 2006). Studies report that prevalence of comorbidity is even higher in residential AOD-treatment program than that in other treatment settings (e.g., outpatient, inpatient)(Greenbaum et al., 1991; Williams & Chang, 2000). A recent study of adolescents referred to a residential program in Australia reported that a quarter of the adolescents who were eligible for the residential treatment had clinically significant level of pre-treatment psychological distress (i.e., Brief Symptoms Inventory (BSI) global severity index t-score ≥63), with greater proportion among females (46%) than the proportion among males (17%) (Bista et al., 2021).

Some recent efforts have been made to address co-occurring psychiatric disorder in many AOD treatment programs including residential program (Brewer et al., 2017; Nathan et al., 2020). Residential AOD-program for adolescents offers a holistic approach with a high level intensive care and support for adolescents with severe AOD use problems along with complex mental health, family, or criminal justice involvement (Morral et al., 2004; Nathan et al., 2020; Nathan et al., 2016b; Williams & Chang, 2000; Winters et al., 2014). However, mental health conditions of AOD-using adolescents in AOD-treatment programs are often undetected and untreated (Hawkins, 2009; Knudsen, 2009; Low et al., 2012). Despite significant advances have been made in AOD-treatment programs during recent decades and a body of controlled research studies suggesting evidence-based 'integrated' intervention to simultaneously treat both AOD-use and mental health problems of adolescents (Hawkins, 2009; Winters et al., 2018; Winters et al., 2014), it is unclear to what extent these interventions have been generalisable and utilised in a wider community of AOD-treatment programs including residential program (Winters et al., 2018). More importantly, there is a dearth of robust controlled longitudinal outcome research to evaluate the effectiveness of improved treatment including evidence-based interventions in residential program for adolescents in treating both AOD use and mental health problems simultaneously. Particularly, the two approaches, 12-step

approach and Therapeutic Communities (TC), despite being widely utilised in residential AOD-treatment programs for adolescents for a long time and as the core treatment approaches, have received a very little robust investigation including clinical trials(Winters et al., 2018).

Among a small body of research on effectiveness of residential program for adolescents, only a few studies have investigated mental health outcomes (Albertella & Norberg, 2012; Edelen et al., 2010; Hser et al., 2001; Morral et al., 2004; Nathan et al., 2020; Whitten et al., 2022) and outcomes where there are co-morbidities (Bean et al., 2005; Crowley et al., 1998; Grella et al., 2001; Nathan et al., 2020; Shane et al., 2003). Most of these studies were short-term and investigated mental health outcomes have found positive residential AOD treatment effects, i.e., reduced mental problems or symptoms (e.g., anxiety, depression, conduct disorder, or other symptoms including self-harm and suicidal ideation), or improved psychological functioning at 3, 6, or 12-months post-treatment (Albertella & Norberg, 2012; Hser et al., 2001; Morral et al., 2004; Nathan et al., 2020). However, studies on AOD treatment outcomes of adolescents with comorbid mental health problems (e.g., depression, anxiety, ADHD, conduct disorder, or internalising or externalising behavioural problems) found that AOD treatment effects on post-treatment AOD use and mental health outcomes were not positive or less effective compared to non-comorbid adolescent group, suggesting that comorbidities can profoundly limit treatment effectiveness (Grella et al., 2001; Shane et al., 2003). We have identified only two studies that have examined long-term mental health outcomes of adolescents attending residential AOD programs with therapeutic community (TC) approach (Edelen et al., 2010; Whitten et al., 2022). However, the findings are mixed due to methodological differences, particularly in using comparison groups. Edelen et al. (2010) show that positive effects of TC (compared with non-TC) gained in the short-term (one-year post-treatment) erode over time with no evidence in the long-term (>5 years). A more recent study in Australia, however, suggests that staying in treatment for 30 days or more (i.e., TC completion group, compared with non-completion group) may decrease hospitalisations for a range of conditions including mental health for up to 15 years post-program (Whitten et al., 2022). These studies investigated an overall longitudinal mental health trajectory for the cohort. However, what is unknown in the literature is heterogeneity in AOD-treatment responses among subgroups of adolescents, particularly those with comorbid mental health problems at intake, reflected in different trajectories of mental health outcomes over time following residential AOD-treatment.

An emerging small body of research examining long-term developmental patterns of AOD-use of young people following AOD-program (outpatient or inpatient) suggests existence of different subgroups with distinct developmental trajectory patterns of AOD-use over time, indicating some groups experience positive treatment effects (e.g., abstinent or reduction in use) which are largely maintained, whereas for

others problematic AOD-use continue into their adulthood (Anderson et al., 2010; Campbell et al., 2016; Chung et al., 2008; Godley et al., 2004). Similarly, regarding the trajectories of mental health outcome of AOD treatment, a US study of adult AOD-using women found different mental health service use patterns over eight years after AOD treatment, with consistently low trajectory for most of treated women, but a quarter of the women showed different mental health service use patterns that decreased immediately after treatment and then increased, increased after treatment, and consistently high (Evans et al., 2015). However, long-term mental health service utilisation patterns of adolescents referred to residential AOD-treatment is unknown. Understanding these trajectory patterns over time from adolescence to emerging adulthood to adulthood and what predicts variations in those patterns has important implications for early identifying high-risk subgroups and employing targeted interventions for these young people.

Therefore, the current study investigates long-term trajectory patterns of mental health service utilisations, i.e., mental health related hospitalisations (MH-hospitalisations) of adolescents referred to residential (TC) program for problematic AOD-use, using longitudinal linked hospital admission data following up to 16 years post-program. Specific aims are: (1) estimate crude rates of MH-hospitalisations for the cohort; (2) identify distinct trajectory patterns of MH-hospitalisations post-program from adolescence to adulthood, and (3) examine association of pre-treatment individual and program variables with identified trajectory groups.

6.4 Methods

6.4.1 Study design and participants

This is a retrospective cohort study of young people (13-18 years) who were enrolled in a residential program for problematic AOD use in New South Wales (NSW) and the Australian Capital Territory (ACT), Australia from 1 January 2001 to 31 December 2016 (N=3639). The program, known as PALM (Program for Adolescent Life Management), is a modified therapeutic community (TC) program in a residential setting for adolescents, providing care and support for up to three months and continuing-care for up to three years. Participants were referred to PALM by the youth justice system, police, case workers and clinicians or by family or self-referral and assessed by expert staff for their program eligibility using the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) criteria for substance abuse or dependence over the past 12 months. The details of PALM residential program have been published elsewhere (Foster et al., 2010; Nathan et al., 2016a). PALM data of participants were linked to admitted patient hospital records from all public and private hospitals in NSW and ACT, which collected de-identified mental health related hospital records on admission and separation dates, primary and secondary disease diagnosis codes using the 10th revision of the International Classification of Disease-Australian Modification (ICD-10-AM).

Of 3639 PALM clients, the current study included 3529 participants (73% males, 43% identifying as Aboriginal and/or Torres Strait Islander, and median age of 16.8 years at referral), and excluded 110 participants based on the exclusion criteria: participants whose assessment date (or admission date if assessment date was missing) was not within the study period (1 January 2001- 31 December 2016), or who were not aged 13-18 years, or if both assessment and admission dates were missing. The excluded participants (n=110) were: 74 participants having assessment dates outside the study period, 31 meeting at least one of the other exclusion criteria, and an additional five having data entry errors in the hospitalisation records. The follow-up of MH-hospitalisations of the cohort (n=3529) began from the residential program exit date (or assessment date if not enrolled) until 31 December 2016.

6.4.2 Measures

Outcome variable

The outcome variable was the number of mental health related hospital admissions (MH-hospitalisations) during every 12-month period from the exit date from the residential program (or assessment date if not enrolled) until 31 December 2016 or death if occurred before this date. MH-hospitalisations were defined as the mental health related hospital admissions with ICD-10-AM diagnosis codes from the linked hospital admission data: mental and behavioural (F01-F99, primary diagnosis); intentional self-harm (X60-X84, secondary diagnosis); late effects of intentional self-harm (Y87.0, secondary diagnosis); suicidal ideation, i.e., attempted suicide without injuries (R45.81, primary diagnosis); and attempted self-injury (harm) or symptoms involving emotional states (R45.89, primary diagnosis).

Exposure variable

Length of the exposure to PALM program for the participants was measured by the days in the residential program received before MH-hospitalisation follow-up began, and categorised in three groups as: (a) ‘days>30’, who stayed in program over 30 days up to three months (40.1%, n= 1414), (b) ‘days≤30’, who stayed four to 30 days, not completing program as planned (24.9%, n=877), and (c) ‘non-attend’, who were referred/assessed but did not attend program or attended only up to 3 days (35.1%, n=1238). The ‘non-attend’ group was the comparison group for the analysis. Although detailed data were not available on reasons for not-attending the program, the recorded reasons included: being refused bail, assessed as not being eligible, or loss of interest (Dixson et al., 2018; Nathan et al., 2020).

Pre-program covariates

The covariates or factors known to be associated with program engagement and retention which is likely to then influence outcomes used for this study included: age at referral; sex at birth (male/female); identifying as Aboriginal and/or Torres Strait Islander Australians (herein referred to as 'Aboriginal Australians' as the term recommended by Aboriginal Health and Medical Research Council for NSW (Aboriginal Health and Medical Research Council, 2015)) (dichotomised: Aboriginal/non-Aboriginal); pre-program involvement of youth justice system (justice department or court) or police (dichotomised: justice-involved/non-involved); psychological symptoms measured by Brief Symptoms Inventory (BSI) Global Severity Index (GSI) T-score (dichotomised: GSI<63/GSI≥63) from (Derogatis, 1993); DSM-IV substance dependence score (dichotomised: score≤5/score>5), and principal drug of concern (DoC) at referral (categorised: opioids; cannabis/hallucinogens/tranquilisers; alcohol; and amphetamines/ERD/cocaine/inhalants). The descriptions of these covariates are provided in Supplementary Appendix 2.

6.4.3 Statistical analysis

Descriptive analysis was conducted using chi-square tests for categorical variables and t-tests for the continuous variables. Statistical analysis was proceeded in 3-stages: First, we estimated overall crude and adjusted rates of MH-hospitalisations for the cohort after residential program using person-years and corresponding rate ratios (RR) by various baseline characteristics. The total person-years for each participant was calculated using the person's time in the study starting from the first assessment date for the PALM program (or the first PALM admission date if assessment date was missing) until 31 December 2016 or death. We also estimated adjusted incidence rates and rate ratios (IRR) for overall MH-hospitalisations using negative binomial regression, adjusting for age (at referral), sex (at birth), Aboriginal identity, program-attending groups and person-years. These analyses were performed in SAS Studio version 3.8 and R Studio programs.

Second, we estimated growth mixture model (GMM) using Mplus Version 8.7 to identify trajectory classes of MH-hospitalisations post residential program. For GMM, we used a sub-sample (n=3346) who exited from the program by 31 December 2015, allowing at least one-year and up to 14 years of follow-up post-program. Due to sparse yearly number of MH-hospitalisations, we collapsed two adjacent yearly follow-up data for 14 years converting to seven two-yearly data. Thus, we used seven metric time points for the GMM, each time representing number of MH-hospitalisations during every two-year period, using time 1 (first two years) as the initial time-point (intercept). We estimated unconditional GMMs specifying with varying number of classes (i.e., one- to five-class

models) with linear and quadratic slopes allowing variances of intercept growth factor and residual variances to vary across classes, but the slope growth factor variance was fixed at zero due to convergence problem. Model fit was assessed using a combination of fit indices including smaller values of Akaike information criterion (AIC), Bayesian information criterion (BIC), and sample-adjusted BIC (SaBIC), and a significant p-value (<0.05) of Lo-Mendell-Rubin likelihood ratio test (LRT). Also, classification quality (average posterior probability >0.7 indicative of good precision of membership assignment) and substantive importance of the trajectory groups including class sizes and trajectory shape were considered for the model selection (Muthén & Muthén, 2000; van der Nest et al., 2020). After selecting the optimal unconditional GMM, we reran this unconditional GMM using the manual three-step BCH method (Asparouhov & Muthen, 2021; Asparouhov & Muthén, 2014; Bolck et al., 2004) where weights for each individual were saved in this step for the regression model in the next step. The BCH weights take account of the measurement error of the latent class variable (Asparouhov & Muthen, 2021; Asparouhov & Muthén, 2014).

Third, a predictive model using multinomial logistic regression was estimated to identify the baseline (pre-program and program) predictors of latent trajectory classes. Using BCH weights, this model was specified including all baseline variables simultaneously allowing the estimates of predictors controlling for the effects of other predictors. Odds ratios (ORs) and significant estimates were reported. All models were conducted in Mplus Version 8.7.

Missing data

Missing data in MH-hospitalisations due to a study design was considered a missing at random (MAR) and handled using the full information maximum likelihood (FIML) estimation with robust standard errors (MLR) in Mplus (Enders, 2010; Muthén & Muthén, 2010). Prior to performing multinomial logistic regression, missing data in covariates were imputed with BCH method using weights and multiple imputation approach using 100 datasets (Asparouhov & Muthen, 2021; Asparouhov & Muthén, 2014).

6.5 Results

6.5.1 Baseline (pre-treatment and treatment) characteristics of sample

Table 8 presents baseline sample characteristics of adolescents aged 13 to 18 years (N=3529). Among those who responded to the substance use, mental health and trauma related questions during assessment, over two-thirds (68%, n=1980) of the respondents (n=2897) had high substance dependence scores (DSM-IV scores>5), with a larger proportion of females having greater severity of

dependence than males (76% vs 66%, P<.0001). Although alcohol, cannabis, amphetamines, ecstasy/related drugs (ERD), and opioids were the common drug of concern (DoC) requiring treatment, the majority (91%) of the respondents reported poly-drug use, with a larger proportion of females reporting poly-drugs use than males (94% vs 90%; P= 0.0178). More males than females (57% vs 34%, P<0.0001), and young Aboriginal than non-Aboriginal participants (63% vs 41%, P<.0001) reported being involved with the youth justice system/police/court.

A quarter (26%, n=682) of BSI respondents reported clinical psychological distress level (GSI T-score ≥63). Females were more likely to report high clinical distress levels than males (47% vs 18%; P<0.0001). Around a third of the cohort reported ever attempting suicide (30%, n=1074) or self-harming (32%, n=1117), half (50%, n=1774) experienced physical assault by known and 15% (n=545) experienced sexual assault by known.

Table 8: Pre-program and program characteristics of sample by sex, 2001-2016 (N=3529)

Characteristics	Total (N=3529)	Male (n=2567)	Female (n=962)	Chi-square p-values
Aboriginal identity				
Aboriginal and/or Torres Strait Islander	1499 (43%)	1164 (45%)	335 (35%)	<.0001
Non-Indigenous	2030 (57%)	1403 (55%)	627 (65%)	
Program-attend groups				
Non-attend	1238 (35%)	903 (35%)	335 (35%)	
Days ≤30	877 (25%)	640 (25%)	237 (25%)	0.9402
Days >30	1414 (40%)	1024 (40%)	390 (41%)	
Age at referral (years)				
13-14	324 (9%)	198 (8%)	126 (13%)	
15-16	1734 (49%)	1229 (48%)	505 (52%)	<.0001
17-18	1471 (42%)	1140 (44%)	331 (35%)	
DSM-IV Substance Dependence Score (≥3) (respondents: n=2897)[a]				
Score ≤5	917 (32%)	728 (35%)	189 (24%)	<.0001
Score >5	1980 (68%)	1382 (66%)	598 (76%)	
Principal drug of concern at assessment (respondents: n=2696)[b]				
Alcohol	1000 (37%)	747 (38%)	253 (34%)	
Cannabis	563 (21%)	432 (22%)	131 (18%)	
Amphetamines	528 (20%)	361 (18%)	167 (23%)	
Ecstasy and related drugs (ERD)	373 (14%)	261 (13%)	112 (15%)	
Opioids[c]	132 (5%)	79 (4%)	53 (7%)	
Cocaine	29 (1%)	21 (1%)	8 (1%)	
Other[d]	71 (3%)	54 (3%)	17 (2%)	
Poly-drug use - last 3 months at assessment (respondents: n=1946)[a]				
Yes	1776 (91%)	1281 (90%)	495 (94%)	0.0178
No	170 (9%)	137 (10%)	33 (6%)	
Youth justice system involvement (respondents: n=2908)[a]				
Justice-involved	1476 (51%)	1206 (57%)	270 (34%)	<.0001
Non-involved	1432 (49%)	907 (43%)	525 (66%)	
Number of places lived last six months prior to referral (n=2647)[a]				
1-2 places	1495 (56%)	1157 (60%)	338 (46%)	<.0001
3-7 places	1152 (44%)	762 (40%)	390 (54%)	
BSI Global Severity Index (respondents: n=2624)[a]				
GSI T-score <63	1942 (74%)	1556 (82%)	386 (53%)	<.0001
GSI T-score ≥63	682 (26%)	336 (18%)	346 (47%)	
Mental health issues at assessment [b]				
Attempted, end life- ever	1074 (30%)	611 (24%)	463 (48%)	
Attempted, end life- in last 3 months	393 (11%)	219 (9%)	174 (18%)	
Self-harmed - ever	1117 (32%)	647 (25%)	470 (49%)	
Self-harmed- in last 3 months	388 (11%)	214 (8%)	174 (18%)	
Trauma - experienced/witnessed [b]				
Physical assault-known	1774 (50%)	1209 (47%)	565 (59%)	
Physical assault-stranger	1305 (37%)	1008 (39%)	297 (31%)	
Sexual assault-known	545 (15%)	192 (7%)	353 (37%)	
Sexual assault-stranger	278 (8%)	94 (4%)	184 (19%)	
Verbal abuse	1212 (34%)	759 (30%)	453 (47%)	

[a] Numbers and percentages are presented as per available data on this variable.

[b] 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%).

[c] 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).

[d] Other includes inhalants, hallucinogens, tranquiliser, and other unspecified, which were combined due to small values (<5) in some cells.

6.5.2 Crude and adjusted rates and rate ratios (RRs) of mental health hospitalisations

Table 9 presents post-program crude and adjusted mental health (MH) hospitalisation rates [95% confidence intervals (CI] for overall sample and rates by baseline characteristics. Follow-up of participants (n=3529) up to 16 years (28782 person-years) revealed a total of 5397 MH-hospitalisations, resulting in a hospitalisation crude rate of 188 per 1000 person-years [95% CI: 183.0-192.58]. Almost half of the participants (n=1692, 48%) had at least one or more MH-hospitalisations during the study period and 40% of the MH-hospitalisations involved psychoactive substances (F11-F19). Both crude and adjusted MH-hospitalisation rates were higher for females than males (RR: 1.74 [1.41-1.57], adjusted RR: 1.84 [1.56-2.17]), older aged participants (17-18 years) than 13-14 years group (RR: 1.28 [1.15-1.42], adjusted RR: 1.36 [1.03-1.79]), and both program groups (days≤ 30 and days>30) than non-attend-group with 31% higher for days≤30 group (RR: 1.31 [1.22-1.41]; adjusted RR: 1.36 [1.07-1.59]) and 22% higher for days>30 group (RR: 1.22 [1.15-1.30]), but the adjusted rate for days>30 group was not significantly different to the non-attending group. MH-hospitalisation rates were not different between Aboriginal Australians and non-Indigenous participants (RR: 1.08 [1.02-1.26], adjusted RR:1.07 (0.92-1.25).

Additionally, crude rates were 33% greater for those who had higher DSM-IV substance dependence score (score>5) (RR: 1.33 [1.24-1.42]), two times greater for those with greater psychological problems (GSI≥63) (RR: 2.28 [2.14-2.43)]), and 46% greater for those who used poly-drug last three months at assessment (RR: 1.46 [1.19-1.80]). However, the MH-hospitalisation rates were 35% lower for those who were referred by justice system (justice-involved) than non-involved participants (RR: 0.65 [0.61-0.69]), and 13% lower for those having amphetamines/ERD/cocaine/inhalants as their drug of concern (DoC) at referral than those with alcohol as DoC (RR: 0.87 [0.80-0.95]).

Table 9: Crude and adjusted mental health hospitalisation incidence rates (IR) and rate ratios (RR) for the study period (2001-2016) by demographic and other baseline characteristics at referral

Crude AOD hospitalisation rates and rate ratios						
	Number of participants (%)	**Total counts of mental health hospitalisations**	**Person-years**	**Mental health hospitalisation rate per 1000 person-years (95% CI)**	**Rate Ratio (RR) (95% CI)**	**P-value**
MH* hospitalistion (total sample)	3529	5397	28781.84	187.51 (183.0-192.58)		
MH* hospitalisations: psychoactive substance use - involved	845a (24%)	2170	28781.84	75.40 (72.26-78.64)	*1.0 (reference)*	
MH* hospitalisations: psychoactive substance use - not involved	847a (24%)	3227	28781.84	112.12 (108.28-116.06)	**1.49 (1.41-1.57)**	**<.0001**
Gender						
Male	2567 (73%)	3257	20883.36	155.96 (150.65-161.41)	*1.0 (reference)*	
Female	962 (27%)	2140	7898.48	270.94 (259.58-282.67)	**1.74 (1.65-1.88)**	**<.0001**
Indigenous status						
Non-Indigenous	2030 (58%)	3088	16977.12	181.89 (175.53-188.42)	*1.0 (reference)*	
Indigenous	1499 (42%)	2309	11804.72	195.60 (187.70-203.74)	**1.08 (1.02-1.13)**	**0.0083**
Age group at referal (years)						
13-14	324 (9%)	406	2560.66	158.55 (143.50-174.75)	*1.0 (reference)*	
15-16	1734 (49%)	2521	14045.97	179.48 (172.54-186.63)	**1.13 (1.02-1.26)**	**0.0203**
17-18	1471 (42%)	2470	12175.2	202.87 (194.95-211.03)	**1.28 (1.15-1.42)**	**<.0001**
Program groups						
Non-attend	1238 (35%)	1654	10265.6	161.12 (153.45-169.08)	*1.0 (reference)*	
Days ≤30	877 (25%)	1419	6711.27	211.44 (200.58-222.73)	**1.31 (1.22-1.41)**	**<.0001**
Days >30	1414 (40%)	2324	11804.96	196.87 (188.94-205.04)	**1.22 (1.15-1.30)**	**<.0001**
DSM-IV Substance Dependence Score	(n=2897) [b, c]					
≤ 5	917 (32%)	1040	6450.24	161.23 (151.58-171.34)	*1.0 (reference)*	
6-7	1980 (68%)	3214	15002.53	214.23 (206.89-221.77)	**1.33 (1.24-1.42)**	**<.0001**
Global Severity Index (GSI) score	(n = 2624)[c]					
< 63	1942 (74%)	1987	13588.48	146.23 (139.87-152.80)	*1.0 (reference)*	
≥63	682 (26%)	1636	4908.19	333.32 (317.36-349.87)	**2.28 (2.14-2.43)**	**<.0001**
Youth justice system involvedd	(n = 2908)[c]					
No	1432 (49%)	3096	13747.4	225.21 (217.34-233.28)	*1.0 (reference)*	
Yes	1476 (51%)	1140	7807.46	146.01 (137.66-154.74)	**0.65 (0.61-0.69)**	**<.0001**
Drug of concern (Doc) at referral	(n=2696)[c]					
Opioids and other	147 (5%)	330	1830.38	180.29 (161.36-200.83)	0.91 (0.80-1.03)	0.1279
Cannabis, Halluc**, tranq**	598 (22%)	1295	6374.58	203.15 (192.24-214.52)	1.02 (0.95-1.11)	0.5539
Alcohol	1000 (37%)	1126	5677.99	198.31 (186.89-210.24)	*1.0 (reference)*	
ERD, Amph**, cocaine, inhalants	951 (35%)	938	5447.7	172.18 (161.34-183.56)	**0.87 (0.80-0.95)**	**0.0014**
Poly-drug use (last 3 months at assessment)	(n=1946)[c]					
No	170 (9%)	94	799.46	117.58 (95.02-143.89)	*1.0 (reference)*	
Yes	1776 (91%)	1556	9050.28	171.92 (163.49-180.69)	**1.46 (1.19-1.80)**	**0.0003**

Adjusted mental health hospitalisation estimates and rate ratios (negative binomial regression)				
	Estimates	**SE**	**P-value**	**Rate Ratios (RR) (95% CI)**
Female (Ref: male)	0.6102	0.0841	**<.0001**	**1.84 (1.56-2.17)**
Aboriginal (Ref: Non-Indigenous)	0.0697	0.0773	0.3673	1.07 (0.92-1.25)
Age at referral (years)				
15-16 (Ref: 13-14 years)	0.1379	0.1403	0.3257	1.15 (0.87-1.51)
17-18 (Ref: 13-14 years)	0.306	0.1422	**0.0314**	**1.36 (1.03-1.79)**
Program groups				
Days ≤30 (Ref: Non-attend)	0.2689	0.1008	**0.0076**	**1.31 (1.07-1.59)**
Days >30 (Ref: Non-attend)	0.1219	0.088	0.1661	1.13 (0.95-1.34)

*MH = mental health; Halluc**=Hallucinogen, tranq**= Tranquiliser, Amph**=Amphetamines

[a] 1274 (36.1%) of the sample (3529) had at least one or more mental health hospitalisations, and when mental health hospitalisations were categorised to non-psychoactive and psychoactive substance use hospittalsation types, 418 participants appeared to be overlapped in both hospitalisations and therefore the total number of participants from these two categories did not add to 1275.

[b] 2.8% of 2897 had substance dependence score <3 indicating they did not meet the substance dependence criteria.

[c] Smaller sample was used due to missing data in this variable.

6.5.3 Identifying mental health hospitalisation trajectories using growth mixture models (GMM)

Table 10 presents comparisons of model fit indices and other selection criteria for up-to 5-class unconditional GMMs. Based on smaller model fit indices (AIC: 17912.68, BIC: 18004.41, and SaBIC: 17956.751), significant LMR-LRT p-value (<0.05), and better classification quality, we selected three-class model as the optimal model for the post-program MH-hospitalisation trajectories of young people.

Table 10: Model fit indices and criteria for one- through five-class trajectory models (GMMs)

GMM NB*	No. of parameters	LL H_0	AIC	BIC	Sample-size Adjusted BIC	LMR test p-value	Estimated sample size per class (%)	Entropy	Average posterior probabilities for most likely latent class membership, per class
1-Class	11	-9051.19	18124.38	18191.65	18156.70				
2-Class i	16	-8960.20	17952.41	18050.26	17999.42		30/70	0.35	.81/.81
2-Class i, r	11	-8962.30	17946.61	18013.88	17978.92		27.5/72.5	0.38	.82/.82
3-Class i	21	-8938.25	17918.50	18046.93	17980.20		23/47/30	0.26	.62/.63/.76
3-Class i, r	**15**	**-8941.34**	**17912.68**	**18004.41**	**17956.75**	**0.0001**	**7/72/21**	**0.51**	**.75/.81/.67**
4-Class i	26	-8930.17	17912.34	18071.34	17988.73		26/27/43/4	0.33	.73/.63/.58/.68
4-Class i, r	23	-8923.165	17892.329	18032.99	17959.91		20/1/57/22	0.45	.56/.75/0.71/0.72

* i: Variances of intercept growth factor allowed to vary across classes; r: Residual variances of outcomes at each time allowed to vary across classes but restricted to be equal within-class; LMR test was conducted for the selected model only.

Figure 3: Trajectory classes of mental health hospitalisation of young people referred to residential program from 2001 to 2015 (n=3446) and followed-up for 14 years post-program

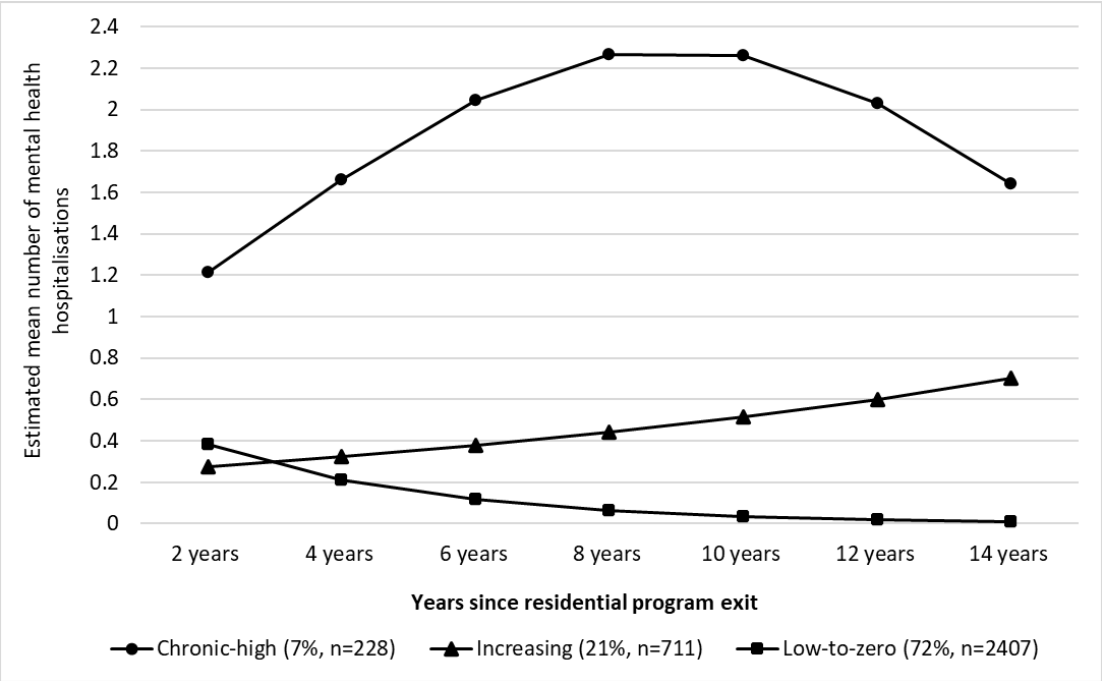

Figure 3 shows the three distinct estimated trajectory curves from the selected 3-class model which included *chronic-high* (7%, n=228), *increasing* (21%, n=711), and *low-to-zero* (72.0%, n = 2407) classes. Wald chi-square tests showed that the three trajectory classes were significantly different, i.e., (Wald chi-square values for intercept factor= 18.15, p=0.0001 and slope factor=170.15, p<.0001).

6.5.4 Descriptive characteristics of participants classified in three trajectory classes

Table 11: Descriptive characteristics of participants belonging to three latent trajectory classes based on the most likely latent class membership, (n=3346)

Characteristics	Total (n=3346)	Chronic-high (n=128)[a]	Low-to-zero (n=2892)[a]	Increasing (n=326)[a]
Sex				
Male	2434 (72.7%)	85 (3.5%)	2118 (87.0%)	231 (9.5%)
Female	912 (27.3%)	43 (4.7%)	774 (84.9%)	95 (10.4%)
Aboriginal status				
Aboriginal and/or Torres Strait Islander	1426 (42.6%)	64 (4.5%)	1202 (84.3%)	160 (11.2%)
Non-Indigenous	1920 (57.4%)	64 (3.3%)	1690 (88.0%)	166 (8.6%)
Age group at referral (years)				
13-14	302 (9.0%)	10 (3.3%)	267 (88.4%)	25 (8.3%)
15-16	1648 (49.3%)	57 (3.5%)	1441 (87.4%)	150 (9.1%)
17-18	1396 (41.7%)	61 (4.4%)	1184 (84.8%)	151 (10.8%)
Program groups				
Non-attend	1179 (35.2%)	37 (3.1%)	1040 (88.2%)	102 (8.7%)
Non-complete (<=30days)	807 (24.1%)	37 (4.6%)	676 (83.8%)	94 (11.6%)
Over 30days (>30days)	1360 (40.6%)	54 (4.0%)	1176 (86.5%)	130 (9.6%)
DSM-IV Substance Dependence Score	(n=2714) [b, c]			
score ≤ 5	862 (31.8%)	33 (3.8%)	766 (88.9%)	63 (7.3%)
score 6-7	1852 (68.2%)	71 (3.8%)	1596 (86.2%)	185 (10.0%)
BSI Global Severity Index (GSI) score	(n = 2445) [c]			
< 63	1812 (74.1%)	55 (3.0%)	1629 (89.9%)	128 (7.1%)
≥63	633 (25.9%)	36 (5.7%)	532 (84.0%)	65 (10.3%)
Youth justice system involved [d]	(n = 2725) [c]			
Non-involved	1361 (49.9%)	73 (5.4%)	1106 (81.3%)	182 (13.4%)
Justice-involved	1364 (50.1%)	30 (2.2%)	1268 (93.0%)	66 (4.8%)
Drug of concern (DoC) at referral	(n=2513) [c]			
Opioids and other	147 (5.8%)	6 (4.1%)	113 (76.9%)	28 (19.0%)
Cannabis/Halluc**/tranq**	596 (23.7%)	36 (6.0%)	477 (80.0%)	83 (13.9%)
Alcohol	918 (36.5%)	23 (2.5%)	852 (92.8%)	43 (4.7%)
Amph**/ERD/cocaine/inhalants	852 (33.9%)	20 (2.3%)	774 (90.8%)	58 (6.8%)
Poly-drug use (last 3 months at assessment)	(n=1766) [c]			
No	147 (8.3%)	3 (2.0%)	137 (93.2%)	7 (4.8%)
Yes	1619 (91.7%)	42 (2.6%)	1505 (93.0%)	72 (4.4%)
Number of places lived last 6 months	(n=2465) [c]			
1-2 places	1381 (56.0%)	31 (2.2%)	1253 (90.7%)	97 (7.0%)
3-7 places	1084 (44.0%)	52 (4.8%)	923 (85.1%)	109 (10.1%)

[a] Numbers and proportions of classes were based on the most likely latent class membership, which are slightly different to the model estimated proportions.
[b] 2.8% of 2897 had substance dependence score <3 indicating they did not meet the substance dependence criteria; however, some may meet substance abuse criteria.
[c] Smaller sample was used due to missing data in this variable.
*MH = mental health; ** Halluc=Hallucinogen, tranq= Tranquiliser, Amph=Amphetamines; ERD=Ecstasy related drugs

6.5.5 Predictors of mental health hospitalisation trajectory classes

Table 12 presents the estimates of multinomial logistic regression to assess which baseline variables significantly predicted the trajectory class membership, controlling for the effects of other predictors. Compared to the *low-to-zero* class, participants in the *chronic-high* class were

significantly more likely to identify as Aboriginal Australians (OR = 3.04 [1.68-5.53]), have a higher GSI score (GSI ≥63) (OR = 2.33 [1.14-4.75]), report cannabis/hallucinogens/tranquilizer as their drug of concern (DoC) at referral (OR = 2.83 [1.27-6.32], vs. alcohol), and lived in ≥3 places during six months prior to referral (OR = 2.46 [1.20-4.50], vs places ≤2). Justice-involved participants (vs. non-involved) were significantly less likely to be in this higher trajectory group (OR = 0.28 [0.13-0.58]). Odds of being in *chronic-high* class were not different between females and males, and between program-attend groups (Days ≤30, Days >30 vs Non-attend).

Participants in the *increasing* group, compared to *low-to-zero*, were significantly more likely to be older (>mean age) at referral (OR = 1.48 [1.08-2.03]) and identify as young Aboriginal Australians (OR = 3.03 [1.56-5.86]), and less likely to be justice-involved (vs. non-involved) (OR = 0.16 [0.07-0.39]).

In contrast, compared to *chronic-high* and *increasing* groups, participants classified in *low-to-zero* group were more likely to be younger, non-Aboriginal, justice-involved, have less psychological symptoms (GSI<63), reporting alcohol and amphetamines/ERD/cocaine/inhalants as DoC (vs opioids), and have relatively stable living (number of places ≤2). Program-attending groups (Days≤30 and Days>30) were not significantly associated with being in *low-to-zero* group.

Table 12: Predictors of latent trajectory classes of mental health hospitalisations using multinomial logistic regression, 2001-2015 (N=3446)

Predictor variables	Chronic-high (vs. Low-to-zero)		Increasing (vs. Low-to-zero)		Low-to-zero (vs. Chronic-high)		Low-to-zero (vs Increasing)	
	OR [95% CI]	*P*	OR [95% CI]	*P*	OR [95% CI]	*P*	OR [95% CI]	*P*
Referral age [standardised, unit/SD]	1.28 [0.97-1.69]	0.076	**1.48 [1.08-2.03]**	**0.014**	0.78 [0.59-1.03]	0.076	**0.67 [0.49-0.92]**	**0.014**
Aboriginal and/or Torres Strait Islander identity:								
Yes (vs No)	**3.04 [1.68-5.53]**	**<0.001**	**3.03 [1.56-5.86]**	**0.001**	**0.33 [0.18-0.60]**	**<0.001**	**0.33 [0.17-0.64]**	**0.001**
Sex:								
Female (vs Male)	1.21 [0.65-2.26]	0.541	0.92 [0.47-1.82]	0.813	0.82 [0.44-1.53]	0.541	1.09 [0.55-2.14]	0.813
Program:								
Days ≤30 (vs Non-attend)	1.61 [0.76-3.38]	0.211	1.56 [0.74-3.29]	0.242	0.62 [0.30-1.31]	0.211	0.64 [0.30-1.35]	0.242
Days >30 (vs Non-attend)	1.20 [0.60-2.38]	0.609	1.0 [0.50-2.0]	0.997	0.84 [0.42-1.66]	0.609	1.0 [0.50-2.0]	0.997
Global Severity Index (GSI) T-score:								
GSI ≥63 (vs GSI <63)	**2.33 [1.14-4.75]**	**0.02**	1.38 [0.61-3.19]	0.445	**0.43 [0.21-0.88]**	**0.02**	0.72 [0.31-1.66]	0.445
Substance Dependence score:								
Score >5 (vs Score ≤5)	0.73 [0.39-1.37]	0.322	1.36 [0.62-2.98]	0.441	1.38 [0.73-2.59]	0.322	0.74 [0.34-1.61]	0.441
Justice system/police involvement at referral:								
Justice involved- Yes (vs No)	**0.28 [0.13-0.58]**	**0.001**	**0.16 [0.07-0.39]**	**<0.001**	**3.62 [1.73-7.56]**	**0.001**	**6.28 [2.55-15.46]**	**<0.001**
Drug of concern (DoC) at referral:								
Opioids (vs Alcohol)	1.67 [0.35-7.94]	0.516	3.02 [0.82-11.1]	0.096	0.60 [0.13-2.83]	0.516	0.33 [0.09-1.22]	0.096
Cannabis/Halluc*/Tranq* (vs Alcohol)	**2.83 [1.27-6.32]**	**0.011**	2.31 [0.91-5.87]	0.078	**0.35 [0.16-0.79]**	**0.011**	0.43 [0.17-1.10]	0.078
Amph*/ERD/Cocaine/Inhal* (vs Alcohol)	0.73 [0.28-1.88]	0.516	1.07 [0.44-2.56]	0.885	1.37 [0.53-3.52]	0.516	0.94 [0.39-2.25]	0.885
Number of places lived last 6 months								
Places >2 (vs Places ≤2)	**2.46 [1.20-4.50]**	**0.014**	1.08 [0.53-2.23]	0.826	**0.41 [0.20-0.83]**	**0.014**	0.92 [0.45-1.90]	0.826

* Halluc= Hallucinogen, Tranq= Tranquiliser, Amph= Amphetamines, Inhal= Inhalants

6.6 Discussion

This study investigates the longer-term mental health among adolescents referred to a residential AOD-program in Australia through examining MH-hospitalisation rates up to 16 years post referral using linked hospital admission data. Further, it identifies distinct MH-hospitalisation trajectories and associated baseline factors of these subgroups of participants. We found substantially high MH-hospitalisation crude rate for this AOD treatment referred group of young people and identified three distinct MH-hospitalisation trajectories from adolescents to adulthood using growth mixture modelling (GMM) and their pre-treatment predictors. These findings revealing the existence of subgroups in the cohort with heterogenous mental health service utilisation patterns are valuable in understanding the heterogeneity in the AOD-treatment responses in the long-term, identifying high-risk subgroups, and providing targeted interventions.

Although no precisely comparable MH-hospitalisation data are available for a sub-population referred to AOD-program, the current study found a substantially elevated MH-hospitalisation crude rate of 188 per 1000 person-years, i.e., approximately one in five per-year for this cohort, compared with a national rate of overnight MH-hospitalisation separations with specialised psychiatric care in the general population of 15-24 years group (6.5 per 1000 population, and 9 per 1000 population in 2015-16) (Australian Institute of Health and Welfare, 2017). Further univariate analysis showed MH-hospitalisation crude rates were higher for females, older at referral, program-attending groups (days≤ 30 and days>30 vs non-attend group), those with greater pre-existing psychological symptoms (GSI≥63 vs GSI<63), higher substance dependence (score>5) and using poly-drugs at referral. Interestingly, however, MH-hospitalisation rates were lower for justice-involved participants (vs non-involved). Adjusted rates (adjusted for referral age, sex, and Aboriginal identity) were higher for females, older-aged, and short-staying group (days≤ 30 vs non-attend), but no difference between longer-stay (days>30) and non-attend groups. Both crude and adjusted rates were not different between Aboriginal Australians and non-Aboriginal participants.

Using GMM, we found three distinct data-driven MH-hospitalisation trajectory classes post-program (*chronic-high*, *increasing*, and *low-to-zero* groups), indicating heterogeneity in AOD-program responses among the participants in both short-term (first follow-up in two years post-program) and long-term (subsequent follow-ups in four years until 14 years post-program) (define?). Our findings revealed that over two-thirds (72%) of the sample (*low-to-zero* group) demonstrated sustained low to complete cessation of MH-hospitalisations over the study period, indicating long-term positive effects of residential program for this group. However, around a third of the sample (28%) was identified as a high-risk group who exhibited increasing (*increasing* group) or persistently high

(*chronic-high*) MH-hospitalisations trajectories over the study period. The *chronic-high* group experienced a substantially higher average MH-hospitalisations since the first follow-up (2-years post-program), with a rapid increasing trend in the subsequent years and peaked at 8- and 10-years of follow-ups and then showed a decreasing trend afterward. However, the level of MH-hospitalisations remained substantially higher at all follow-ups for this group compared to the other two trajectory groups. The *increasing* group initially showed very low average MH-hospitalisations during the first two years post-program, and thereon, it increased steadily at all subsequent follow-ups, indicating that the positive effects gained in the short-term eroded over time for this group. The findings for the two higher trajectory groups (*chronic-high* and *increasing*) suggest that the effects of residential AOD-program on mental health outcomes were not evident in the long-term for these subgroups, highlighting the importance of AOD-programs targeting these higher-risk groups with effective and long-term continuing care and support to maintain the positive effects gained in the short-term on mental health outcomes as evidenced in hospitalisations data.

Further regression analysis revealed that the baseline individual and program characteristics associated with these different trajectories explained the variations found in MH-hospitalisation trajectories. We found that over two-thirds of the sample demonstrating low MH-hospitalisation trajectory (*low-to-zero* group) were more likely to experience less severe baseline adversities including lower psychological distress (GSI<63) and stable living (lived ≤2 places last 6 months), were more likely to be non-Aboriginal, and younger participants (13-15 years). This finding suggests that experiencing less severe adversities, particularly lower comorbid psychological distress, during younger adolescence time have longer-lasting positive impact on mental health of young people requiring less or no MH-hospitalisations from late adolescence through to adulthood.

A novel finding of this study was that the justice-involved participants were three and six times more likely to be in the *low-to-zero* group, compared to *chronic-high* and *increasing* groups respectively. However, the explanation for this strong association is unclear and needs further research. One possible explanation may be: our finding of higher odds of younger, non-Aboriginal participants and those with less severe psychological distress being in *low-to-zero* group indicate that those justice-involved participants classified in *low-to-zero* class are also more likely to be non-Aboriginal, younger, and have less severe psychological distress at intake and therefore show low MH-hospitalisations in the long-term. This is consistent with prior evidence of positive association of a psychiatric disorder in adolescence and a psychiatric disorder in adulthood (Castagnini et al., 2016; Copeland et al., 2013). Also, the justice-involved subgroup had legal requirement of completing AOD treatment (otherwise they would need to face legal consequences) which could have worked as a

motivator or protective factor for this justice-involved group to attend the program and benefit from the holistic and therapeutic approach of PALM program, although our finding does not have evidence to support this explanation because we did not find the significant association of program-attend groups (days≤ 30 and days>30), compared to non-attend group, with the *low-to-zero* trajectory class, and we also did not include an interaction of justice-involved with program-attend groups (days≤ 30 and days>30) for this study due to non-significant interaction and related terms. However, there were 80% of participants who attended PALM for at least 1 day or more (from all groups including non-attend group), and 64% of participants classified in the *low-to-zero* class were from both treatment-attend groups, and the explanation for a strong association of justice-involved participants (93%) with the *low-to-zero* trajectory could indicate that, among the justice-involved participants, those who attended the program may have benefited substantially from the PALM program, in addition to the reasons mentioned earlier (e.g., legal requirement as a motivator or protective factor) or other protective factors (such as resilience, family or other environmental support; (Brown & Ramo, 2006)), and those who did not attend the PALM (non-attend) due to bail condition or other legal reasons may have obtained alternative treatment approaches through other treatment programs, because referring these justice-involved adolescents to PALM suggests that these adolescents need treatment. Although the finding of no difference between treatment groups and the non-attend group also indicates towards this direction of receiving treatment from alternative programs for non-attend group, in addition to the role of other protective factors (e.g., resilience, self-control, willingness to change, family and peers support, better socio-economic status and neighbourhood), the limitation is that we cannot confirm whether the participants from the non-attend group received the AOD treatment from alternative treatment programs other than PALM. Prior research also show that justice system referred adolescents if retained in the AOD treatment demonstrate marked positive outcomes on AOD use and social functioning (Green et al., 2016).

Partially consistent with our finding, a recent study on adolescents treated at PALM found a significant association between PALM completion (>30 days) and a lower rate of mental health hospitalisations for both adolescents with and without criminal involvement (Whitten et al., 2022). This study concluded that the treatment completion group had better outcomes of AOD and mental health hospitalisations, compared to non-completion group. However, there were methodological differences between the current study and that study in that this previous study used Cox proportional regression to estimate an overall single trajectory of mental health hospitalisations for all the individuals in their subsample, which did not take into account the unobserved heterogeneity in the sample. In contrast, the current study used a latent trajectory analysis (GMM), which

estimated three different heterogenous trajectories of mental health hospitalisation of the sample. The analytical sample in the previous study (n=1266) was substantially smaller than the current study (n=3446). More importantly, the previous study compared treatment completion group with non-completion group only, and non-attend group (i.e., a control group) was not included in their analysis, whereas the current study used non-attend group as the comparison group to compare with both treatment-attending groups (days≤ 30 and days>30) in each trajectory class. These methodological differences have resulted in different findings although both studies used the same data from the PALM. In the current study, when compared with non-completion group (days≤ 30), treatment complete group (Days ≤30) had greater odds ratio (although not statistically significant) for being in the *low-to-zero* group, consistent with the findings from the previous study, however, when compared with non-attend group, the treatment completion group (days>30) was not better than the non-attend group. This finding in the current study raises the question if the improvement demonstrated by the *low-to-zero* group is reflecting the PALM treatment effects or there are other explanations as well (e.g., treatment effects in combination with other protective factors), which points to further research.

Another novel finding of our study was that around one-third of the participants who exhibited higher MH-hospitalisation trajectories (*chronic-high* or *increasing*) were more likely to be those who were older (16-18 years) at referral, Aboriginal Australians, experiencing greater pre-existing MH problems (GSI≥63), reporting cannabis/hallucinogens/tranquiliser (vs alcohol) as drug of concern (DoC), and unstable living (≥3 places) at referral, compared to *low-to-zero* group. This finding indicated that those adolescents, particularly young Aboriginal Australians, who experienced greater pre-treatment adversities such higher MH problems (GSI≥63) and unstable living, continued experiencing greater psychological problems and had greater risk of exhibiting higher MH-hospitalisation trajectories (*chronic-high* or *increasing*) from adolescence/late adolescence through to adulthood. Consistent with our finding, a US study on AOD-treated adult women also found that older age, homelessness, and co-occurring disorder diagnosis, among others, were significantly associated with consistently high mental health service use trajectory over eight years post-treatment (Evans et al., 2015). Although our findings indicate that the PALM AOD-program was not effective in reducing pre-existing comorbid severe psychological problems in the long-term, this finding also highlights the challenges of treating both AOD-use and mental health problems of young people simultaneously, particularly when young people including young Aboriginal Australians have multiple other intersecting adversities such as homelessness or unstable living. Our findings support previous evidence suggesting that AOD-use problems with comorbid psychiatric disorders among adolescents is a more challenging clinical phenomenon than either problem alone,

which can impact treatment response and long-term outcomes, with very high risk for continued AOD dependency and mental health problems into adulthood (Burns et al., 2005; Degenhardt et al., 2018; Drake et al., 2005; Grella et al., 2001; National Institute on Drug Abuse, 2018a). Most of the participants in our study reported at least one or more pre-existing mental health problems, with 26% experiencing clinically significant mental health conditions (GSI≥63). These findings highlight that addressing challenges of psychological comorbidities in AOD-programs for adolescents requires better screening and evidence-based integrated treatment models (Brewer et al., 2017) targeting these high-risk vulnerable young people.

We found young Aboriginal Australians had three times greater odds of being in higher MH-hospitalisations trajectories (*chronic-high* and *increasing*). In this study, 43% of participants were young Aboriginal Australians and over a third (>34%) had pre-existing experiences of attempting suicide and/or self-harm. Previous evidence suggest high levels of comorbidity among young Aboriginal Australians (Australian Institute of Health and Welfare, 2018; Gray et al., 2018), with 2 in 5 Aboriginal Australians aged 15-24 reporting long-term mental illness, mainly anxiety disorders, depressive disorders, behavioural or emotional problems and harmful drugs or alcohol use or dependence (Australian Institute of Health and Welfare, 2018). The intentional self-harm and suicide rates among young Aboriginal Australians (<25 years) are some of the highest in the world (Dickson et al., 2019; Dudgeon et al., 2016; Nathan et al., 2020). Young Aboriginal Australians referred to residential AOD program have five times higher mortality rates than the same aged people in the general population (Bista et al., 2021). These findings including the current study finding of higher MH-hospitalisation trajectories among young Aboriginal Australians reflect the complex psychological symptoms experienced by young Aboriginal Australians due to cumulative effects of intergenerational trauma including colonisation, racism, social exclusion, disempowerment, loss, inadequate access to health services and lack of well-funded community-controlled services, and other social determinants including unemployment, incarceration and homelessness (Australian Institute of Health and Welfare, 2018, 2020; Calma et al., 2017; Gray et al., 2018; Gray et al., 2014; Hill et al., 2022; Nathan et al., 2020; Wilkes et al., 2010; Williamson et al., 2018). Unemployment, homelessness, and lack of culturally safe support experienced by these young Aboriginal Australians are likely to exacerbate the existing psychiatric problems, which may explain the finding of current study that those experiencing greater psychological problems (GSI score ≥63) and unstable living (≥3 places) were more likely be in *chronic-high* MH-hospitalisations group. Our findings highlight that one AOD-program cannot address these multiple issues, mainly comorbid mental health issues, and need for a range of other programs and support including in earlier life and in life domains that impact mental health such as housing, employment, etc., and

need for special approaches designed for young Aboriginal Australians by involving Aboriginal staff to engage with these complexities and comorbidities, offering integrated and culturally responsive models of care and continuing care that supports young Aboriginal Australians, their families and communities (Hill et al., 2022; Nathan et al., 2020).

Implications:

The finding of current study of strong and significant association of justice-involved participants with lower to zero mental health hospitalisation trajectory points to a support for residential program for the sub-population referred by the justice system, however, due to no significant difference between treatment groups and the non-attend group, further research is recommended to confirm the support of residential treatment for justice-involved participants. Improvements in mental health hospitalisations over time were not evident in our modelling for those with greater psychological distress and young Aboriginal Australians, who appeared more likely to be associated with higher mental health hospitalisation trajectories. These findings highlight the importance of better screening at referral, culturally responsive and specialised integrated treatment programs targeting MH comorbidity and addressing the needs of young Aboriginal Australian. Longer and effective continuing care is vital to retain the early positive treatment effects gained over the long-term. Further research is needed on the adequacy of the current PALM model of care to address the complex issues of mental health comorbidity, and to inform evidence-based and enhanced integrated models of care.

Strengths:

This is a first study to investigate distinct long-term trajectory patterns of mental health hospitalisation outcomes following referral to a AOD residential program (TC) for adolescents. The novelty of this study also lies in applying a robust methodology by using long-term follow-up linked data and using a treatment non-attending group as a comparison group to compare treatment effects of treatment-attending groups.

Limitations:

First, the current study does not investigate mental health outcomes of participants who utilised different mental health services (e.g., clinics, emergency department, or ambulatory services) other than mental health hospitalisations during the study period, which may have underestimated the actual mental health problems of the participants over time post-referral. Second, we could not determine if participants from the non-attend group had received AOD-treatment from other non-residential programs after their referral to PALM during the study period. Third, self-reported data for the baseline mental health conditions and substance dependence criteria were subject to bias

and errors of recall. Finally, although entropy is not an ideal measure of model fit, with the reported entropy value and the averaged posterior probability of class membership, there could be classification bias introduced when assigning classes.

6.7 Conclusion

In investigating mental health outcome of adolescents referred to a residential AOD-program using linked mental health hospitalisation data, our study found a substantially elevated crude rates of MH-hospitalisations for the cohort compared to the crude rate of general population. We showed heterogeneity in mental health outcomes post--referral using GMM by identifying three distinct MH-hospitalisation trajectories. We found over two-thirds of the sample, particularly those who were younger, non-Aboriginal, justice system involved, had lower psychological distress and stable living, demonstrated sustained low to zero MH-hospitalisation trajectory, indicating positive or improved mental health outcome. However, the mental health outcome appeared to be worsened over time for one-third of participants, particularly young Aboriginal Australians and those with greater pre-referral comorbid mental health problems, who showed chronic-high or increasing MH-hospitalisation trajectories. These findings highlight the importance of better screening at referral, culturally responsive and evidence-based integrated treatment including longer and effective continuing care targeting psychological comorbidity. Further research is needed on the adequacy of current PALM programs to address the mental health comorbidity and cultural needs of young Aboriginal Australians.

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CHAPTER 7: DISCUSSION

In this chapter, I give a summary of each of the three results chapters (Chapter 4 - 6) in section 7.1. In section 7.2, I discuss the overall findings from all three studies from these three chapters (Chapters 4 - 6). In section 7.3, I discuss the strengths and limitations of the research, and in section 7.4 I discuss the implications of the work in this thesis.

7.1 Discussion on Results

This dissertation has raised and answered several questions while examining the three main aims regarding the impact of a residential AOD program on mortality, AOD use and mental health outcomes of referred adolescents who were followed-up for up to 16 years using longitudinal linked mortality and AOD- and MH-related hospitalisation data.

The purpose of this research was to determine evidence on long-term effectiveness of the PALM residential treatment program (TC approach) for adolescents (13 to 18 years) with problematic AOD use by investigating mortality, AOD related hospitalisations, and mental health related hospitalisations of adolescents referred to PALM program, using longitudinal linked data on mortality and hospital admissions following residential PALM program. There were three overarching aims of this dissertation: (1) estimate mortality rates and determine causes of death among adolescents, (2) determine overall AOD-hospitalisation rate for the cohort, identify distinct subgroups of adolescents in the sample with distinct developmental trajectory patterns of AOD-hospitalisations from adolescence through to adulthood, and determine predictors of each trajectory class, and (3) determine overall mental health related hospitalisation rate for the cohort, identify distinct subgroups of referred adolescents with distinct trajectory patterns of mental health related hospitalisations from adolescence into adulthood, and determine predictors of each trajectory class.

7.1.1 Findings of Study 1 (Aim 1)

I found very high mortality rates among residential AOD treatment-seeking young people; five times higher than the general population of the same age (SMR=4.91). The estimated overall crude mortality rate (CMR) was 2.18 deaths per 1000 person-years (all-cause), which was substantially higher than the annual all-cause crude death rates of less than 1 per 1000 persons in the 14-19 years age-group in the NSW general population (Australian Bureau of Statistics, 2017) during the study period of my research.

The SMRs were higher for females (vs males), Aboriginal Australians (vs non-Aboriginal participants), older referral age (15-16- and 17-18-years vs 13-14 age-group), those with greater DSM-IV substance dependence scores (scores 6-7 vs scores 3-5), and those with greater psychological distress (GSI≥ 63 vs GSI<63). Females saw significantly higher overall SMR than males (SMR: 9.6 vs. 4.1; *P* = 0.005), which is consistent with findings from several previous studies including studies in Australia showing higher mortality rates among female participants than male counterparts.

I also found higher mortality rates among treatment-attend groups (days≤30 and days>30) and lower rates among the non-attend group, however, the difference in the rates was not significant (p=0.359). This finding was against the expectation of this thesis that those who attended treatment (days≤30 and days>30) would have better outcomes, compared to those who did not (non-attend group.

Additionally, I found study found that most of deaths (two thirds) involved drug and/or alcohol directly or indirectly. Accidental overdose, mainly opioids (methadone, heroin) or overdose of opioids with combination of other drugs (benzodiazepines, amphetamines, cocaine, other stimulants) was the major cause of death.

7.1.2 Findings of Study 2 (Aim 2)

The novel finding of this study was a substantially elevated overall crude AOD hospitalisation rate of 188 per 1000 person-years (i.e., around one hospitalisation in five person-years) for the cohort following the AOD-program. Although precisely comparable data was not available, the estimated overall rate of AOD-hospitalisations in the current study was substantially higher when comparing with the Australian national crude rates of drug-related hospitalisations for 20-29 age group during the study period from 2001-2016, with the annual crude rate being approximately 400 or >400 drug-related hospitalisations per 100,000 people during this period for this age group (Chrzanowska et al., 2019). Examining differences in the crude rates by estimating rate ratios across the groups of the demographic and pre-treatment variables found significant higher AOD-hospitalisation rates for females (vs males), young Aboriginal Australians (vs non-Indigenous participants), older group at referral (17-18 years vs 13-14 years), both treatment-attend groups (days>30 or days<=30 vs non-attend group), and those who had greater pre-treatment psychological distress (GSI≥63 vs GSI<63). Interestingly, those who were involved in pre-treatment juvenile justice system had significantly lower crude rate of AOD-hospitalisations than those who were not involved in justice system.

From the trajectory analysis, this study identified three heterogenous post-PALM AOD-hospitalisation trajectory patterns (*high-decreasing*, *increasing*, and *low-to-zero* classes) of young

people from adolescence through to early adulthood and adulthood using growth mixture modelling (GMM) following up to 10 years post-PALM. This analysis revealed that most of the participants (97%) who were classified to two trajectory groups: *increasing* and *low-to-zero*, initially exhibited a very low average AOD-hospitalisations during the first follow-up in two-year time (short-term) from the exit of PALM program, reflecting early positive outcome of PALM treatment in the short-term. These early positive effects continued for two-thirds (68%) of the sample (*low-to-zero* group) who exhibited sustained low to desisting AOD-hospitalisations during the 10-year follow-up period. However, for 29% of the sample (*increasing* group), this low AOD-hospitalisations observed initially during the first two years diminished in the subsequent follow-ups and showed increasing AOD-hospitalisations as they transitioned from adolescence/late adolescence to young adulthood to adulthood. Similarly, the third trajectory group in the current study, *high-decreasing*, although small in group size (3% only), has captured a unique pattern of high levels of AOD-hospitalisations throughout the 10-year follow-up period from adolescence to adulthood, reflecting severely AOD-dependence and persistent high AOD-use pattern of participants classified in this trajectory group.

I found that baseline demographic and pre-treatment variables were the key in differentiating these AOD-hospitalisation trajectories of adolescents. The novel and important finding from this study was that two higher AOD-hospitalisation trajectory classes (*increasing* and *high-decreasing*), comprising one-third of the sample, were predicted by identified as Aboriginal Australians (vs non-Aboriginal participants), greater psychological distress (GSI≥63 vs GSI<63), and reporting opioids and Cannabis/hallucinogens/tranquiliser as DoC (vs alcohol and amphetamines/ERD/cocaine/inhalants), compared with *low-to-zero* trajectory group. This analysis found that identified as Aboriginal Australians was strongly associated with both higher AOD-hospitalisation trajectories (*increasing* and *high-decreasing*), with the odds being in the *high-decreasing* group was eight times and being in the *increasing* trajectory group was four times higher for Aboriginal Australians (vs non-Aboriginal), compared to *low-to-zero* trajectory group. The *increasing* class was also predicted by being older at referral and females. In contrast, this study found that non-Aboriginal participants, those who had lower mental health problems (GSI<63), males, younger at referral, those who were involved in justice system, and those having alcohol and amphetamines/ERD/Tranquiliser as DoC at referral (vs opioids and cannabis) were significantly more likely to demonstrate low AOD-hospitalisation trajectory (*low-to-zero* group) post-referral/program, compared to two higher trajectories.

7.1.3 Findings of Study 3 (Aim 3)

The third study on Aim 3 (Study 3) had a goal of assessing effectiveness of PALM residential treatment by investigating mental health related hospitalisations (MH-hospitalisations) of referred adolescents, following up to 16 years post-PALM.

I estimated crude rate of MH-hospitalisations for the cohort and provided evidence of very high MH-hospitalisation crude rate, with approximately one MH-hospitalisation in every five person-years (i.e., 188 per 1000 person-years). Almost half of the participants (n=1692, 48%) had at least one or more MH-hospitalisations during the study period. Although there was no precisely comparable prior research evidence, the MH-hospitalisation rate found in the current study was substantially higher compared with Australian national rates of overnight MH-hospitalisation separations with specialised psychiatric care of 4.7 per 1000 persons in 12-17 age group (i.e., 1 MH-hospitalisation in 212 persons) and 9.57 per 1000 persons in 18-24 years group (i.e., 1 in 104 people) in the general population in 2015-16 (Australian Institute of Health and Welfare, 2017. Cat. no. HSE 192. Canberra: AIHW; https://www.aihw.gov.au/mental-health/topic-areas/admitted-patients#Hospitalisations, downloaded on 2/05/2023).

There were significantly higher MH-hospitalisation crude rates for females (vs males), those who were older (15-18 years vs 13-14 years) at referral, those with greater pre-treatment psychological problems (GSI≥63 vs GSI<63), higher DSM-IV substance dependence (score>5 vs score≤5), and those who reported using poly-drugs at referral. The MH-hospitalisation crude rates were significantly higher for both program-attending groups (days≤ 30 and days>30) compared to non-attend group. As found in AOD-hospitalisation analysis, MH-hospitalisation rates were lower for justice-involved participants (vs non-involved). Similarly, the adjusted MH-hospitalisation rates were significantly higher for females, older participants, and shorter-stay group (days≤30 vs non-attend group), but no difference between longer-stay (days>30) and non-attend groups. Although the crude rate was slightly higher for Aboriginal Australians, adjusted rates were not different between Aboriginal Australians and non-Aboriginal participants.

I found subgroups that showed three distinct MH-hospitalisation trajectory patterns over time from adolescence to young adulthood to adulthood (*chronic-high*, *increasing*, and *low-to*-zero classes). These patterns showed that most of the participants (72%) consistently demonstrated sustained low to complete cessation of MH-hospitalisations from adolescence to adulthood (*low-to-zero* trajectory class); however, around a third of the sample (28%) was identified as a high-risk group who experienced increasing (*increasing* class) or persistently high MH-hospitalisations (*chronic-high* class)

over time. The *chronic-high* group (7%) experienced a substantially higher average MH-hospitalisations than other two trajectory groups from the first follow-up (2-years post-program) during their adolescence until adulthood. The *increasing* group (21%) initially showed very low average MH-hospitalisations during the first two years post-program, but afterwards, their MH-hospitalisations accelerated throughout their emerging adulthood to adulthood.

A novel finding of the current study was that greater pre-treatment adversities such as higher MH problem scores (GSI≥63) and unstable living last six months (≥3 places), and identified as young Aboriginal Australians, older referral age, and reporting cannabis/hallucinogens/tranquiliser as DoC at referral were the significant variables predicting higher MH-hospitalisation trajectories (*chronic-high* or *increasing* class). Another key finding that, as found in the AOD-hospitalisation trajectories, identified as Aboriginal Australian and pre-treatment justice-involved showed strong association with both higher MH-hospitalisation trajectories. Aboriginal Australian were three times more likely to be in these higher trajectories, but those who were involved with justice system were significantly less likely to be associated with these higher MH-hospitalisation trajectories. In contrast, younger and non-Aboriginal participants, those with less severe pre-treatment mental health and living problems, and those involved with justice system were more likely to be associated with *low-to-zero* trajectory class.

7.2 Key findings synthesis across three studies

In this section, I provide a synthesis of the main and most novel findings of my research across the three studies presented in Chapters 4 to 6 and the implications for policy, practice and research.

7.2.1 Finding 1: No difference between treatment groups in the trajectories

The first main finding of this thesis was related to whether outcomes were different across treatment-attend groups (days>30, days≤30) compared with the non-attend group. Evidence from some earlier research suggests that longer stays in AOD treatment and program completion are the most consistent and important predictors of improved treatment outcomes and can reduce relapse in the short-term among adolescents, similar to prior findings for adults and adolescents (Edelen et al., 2007; Hser, Hoffman, et al., 2001; Hser et al., 2004; Jainchill et al., 2000). Based on these prior studies, one could expect that adolescents who attend PALM, particularly those who stayed over 30 days in treatment (days>30 group) will have significantly better outcomes, compared to those who are referred but do not attend or stay less than 30 days. However, prior evidence on impact of

treatment retention or length of stay (LOS) on longer-term outcomes, over a number of years, among adolescents is lacking.

The results in the current thesis were contrary to the findings of earlier research showing longer length of stay was associated with more positive outcomes. The results from all three studies of this thesis showed that the treatment-attend groups compared with the non-attend group had poorer post-PALM outcomes such as higher mortality rates, higher crude AOD- and MH-hospitalisation rates (although not significantly different, P>0.05). Further, the results from trajectory analyses of AOD-hospitalisations and MH-hospitalisations showed no significant difference between effects of treatment-attendance and no treatment (non-attend) in any trajectory class. Instead, the demographic and other pre-treatment variables appeared to be the key to explain the heterogenous patterns of longer-term outcomes and membership of different trajectory groups. In the current study, those who experienced greater pre-treatment adversities, particularly greater pre-treatment mental health problems (GSI≥63) and unstable living (≥3 places), or identified as Aboriginal Australians, showed poorer long-term outcomes regardless of their length of stay in treatment.

The findings that the treatment-attend groups had poorer long-term outcomes in all three studies maybe due to the confounding by indication as above, with the participants in the treatment-attending groups were more likely to be those with greater severity of pre-treatment AOD-use, comorbid psychiatric issues, experience of sexual and physical abuse, and other social and family issues, requiring complex, longer and targeted care. Although young people with these characteristics attended or completed the program, there may not be a significant reduction in adverse outcomes post program, as shown in past research (Dasinger et al., 2004; Dixson et al., 2018; Fickenscher et al., 2006; Nathan, Bethmont, et al., 2016; Nathan et al., 2020; Neumann et al., 2010; Vourakis, 2005) because these young people, particularly those with greater severity of comorbid mental health problems, are less likely to respond to treatment (Ramchand et al., 2014; Shane et al., 2003). Furthermore, evidence suggest that some types of mental health co-occurrence, such as disruptive disorders, are associated with less successful AOD treatment retention and completion (Hulvershorn et al., 2015).

In contrast, an explanation for the finding that the non-attend group had better outcomes including lower mortality rates, lower AOD-, and MH-hospitalisation rates, than treatment-attending groups, may be that the participants from this non-attend group may have received AOD and related mental health services from other service providers (e.g., outpatient, inpatient treatment) after referral to PALM during the study period. However, this information is unknown for this study. Additionally, there may have roles played by some protective factors including individual factors (e.g., resilience,

self-control), familial factors (e.g., parent-adolescent mutual attachment relationship, parental support for deviance from AOD-using peers, parents monitoring), environmental or contextual factors (better socio-economic status or neighbourhood), which buffer the risk factors for continuing AOD use of adolescents and young adults (Brown & Ramo, 2006). Also, although 81% of the sample (65% from the treatment attend groups who attended >3 days, and 16% from the non-attend group who attended 1-3 days) were eligible and attended the program, a proportion of participants from the 19% with no attendance days (0 days from non-attend group) may be ineligible for the program due to less severe presentation at intake including lower comorbid mental health problems or family issues or not meeting the DSM-IV substance abuse/dependence criteria for the AOD treatment. Interaction of these less severe risk factors with some individual, familial or environmental protective factors could enhance the positive outcomes (Brown & Ramo, 2006) for some of these non-attending adolescents.

Similarly, the results from trajectory analyses of AOD-hospitalisations and MH-hospitalisations showed no significant difference between treatment-attend and no treatment (non-attend) groups in any trajectory class. This finding indicates that there is no effect of length of stay in treatment on these measured outcomes in the long-term. This is consistent with some prior research on adults which show that the effect of length of stay in treatment on outcomes may be weak in the long-term, with effects dissipating over time (cited in King & McChargue, 2014). However, there is a paucity of methodologically rigorous studies to provide evidence on impact of treatment retention or LOS on the long-term outcomes of adolescents. A recent long-term study of PALM participants has shown that those who attended PALM treatment for 30 days or over had significantly lower rates of hospitalisations for substance use and mental health problems, compared with that for non-attend group (<30 days in treatment) (Whitten et al., 2022). However, due to absence of no treatment group, this study does not provide conclusive evidence whether the treatment-attending groups have better outcomes than non-attending group (i.e., no treatment), and therefore the findings of this study may not be a reflective of actual AOD treatment effects as suggested by previous review studies (Tripodi, 2009; Williams & Chang, 2000; Winters et al., 2018). Therefore, the disparity observed in the findings between this previous study and the current thesis may be explained by differences in methodologies used in the current study including adjustment of the potential confounding effect of pre-treatment comorbid mental health problems and using non-attend groups as comparison group.

7.2.2 Finding 2: Association of pre-treatment mental health problems with later outcomes

All three studies in this thesis showed that participants who had greater pre-treatment mental health problems (GSI>63) were more likely to have poorer outcomes including higher mortality rates, higher AOD- and MH-hospitalisation rates, and were more likely to be in a higher AOD- and MH-hospitalisation trajectory group. These findings along with Finding 1 above indicate that treatment outcomes depend more on the severity of pre-treatment comorbid mental health problems and other adversities rather than LOS or length of treatment attendance. The association between length of stay and the outcomes being less evident in this study may be due to the confounding effects of these pre-treatment variables.

Finding 2 aligns with the findings from past studies that emphasise an important or moderating role of comorbid mental health in determining the relationship between AOD treatment and later outcomes (King & McChargue, 2014; Shane et al., 2003). For example, a short-term study of adolescents residing in an inpatient substance use treatment (King & McChargue, 2014) found that the relationship between LOS and treatment outcome was differentially moderated by comorbid mental health diagnoses at three months post-treatment, with LOS a positive predictor of abstinence across all time points for those with a lower level of internalising disorders (i.e., ≤1 diagnosed disorder), but not for those with high levels of internalising disorders or those with externalising disorders. However, the current study did not include interaction of comorbidity (GSI>63) with treatment groups to examine moderating effects of comorbidity due to non-significant interaction and related terms in each trajectory. A further study of adolescents entering two different residential AOD treatment programs, short-term and long-term, concluded that the effects of comorbidity were independent of both planned and actual length of stay when controlled for confounding effects of covariates, suggesting that comorbidities can negatively impact treatment outcome in multiple ways, apart from length of stay (Shane et al., 2003). These earlier findings support the findings of the current study showing an association of greater pre-treatment psychological distress (GSI≥63) and other adversities such as unstable living (≥3 places last six months), or if the young person identified as an Aboriginal Australian with higher AOD- or MH-hospitalisation trajectories, compared with lower trajectory (*low-to-zero*), regardless of LOS. The association of greater pre-treatment psychological distress (GSI≥63) with poorer outcomes suggest that AOD-use problems presenting with comorbid psychiatric disorders among adolescents are less likely to respond to an AOD-focussed treatment program. These co-morbidities can then impact longer-term outcomes, with very high risk for continued mental health problems and AOD use problems into adulthood (Degenhardt et al., 2018; National Institute on Drug Abuse, 2018;

Ramchand et al., 2014; Sarala et al., 2020). Young people with comorbid psychiatric problems are also more likely to relapse after AOD treatment (McCarthy et al., 2005).

There is also heterogeneity in the presenting mental health issues and AOD-use among young people referred to treatment, and therefore different subtypes of young people with comorbid mental health issues may respond differently to AOD use focussed treatment (Grella et al., 2001). For example, co-occurring disruptive disorders are associated with less successful treatment completion (Hulvershorn et al., 2015). Other studies have found that in addition to high rates of comorbid psychiatric conditions, there is often experience of sexual and physical abuse alongside several other complex intersecting social and family issues among young people referred to AOD treatment (Dixson et al., 2018; Fickenscher et al., 2006; Neumann et al., 2010; Vourakis, 2005) likely further impacting treatment responses.

In summary, the findings from the current study provide new evidence that baseline factors and their severity are the key to differentiate the long-term outcomes among subgroups of young people, rather than treatment attendance or length of stay. However, this finding of no significant association of length of stay with outcomes may also be because those with higher comorbid mental health and other problems may need more tailored or intensive treatment programs that are not in the current AOD-focussed program (Nathan et al., 2020; Neumann et al., 2010; Shane et al., 2003).

7.2.3 Finding 3 - Justice-involved participants had better outcomes

Over half of those attending PALM treatment (51%) in the current study were referred by the justice system (youth justice department, court, or police) to receive residential treatment for AOD use or AOD-related offences. The results from all three studies showed that participants who had pre-treatment justice system involvement demonstrated improved outcomes, with lower rates of AOD- and MH-hospitalisations than those who were not involved with the justice system. Similarly, justice-involved participants were significantly less likely to be in higher AOD- and MH-hospitalisation trajectories and, conversely, significantly more likely to be in lower trajectory (*low-to-zero*).

Interaction of treatment attendance groups and justice-involvement variables in the AOD-hospitalisation trajectory analysis showed that justice-involved participants from both treatment-attend groups were significantly more likely to be in *low-to-zero* AOD-hospitalisation trajectory group, compared to *increasing* group. This finding indicates that the PALM residential treatment has been most effective for those who were involved in the justice system, compared to those were not involved in the justice system. However, explanations for this finding of justice-involved participants achieving better outcomes in both studies (Aim 2 and Aim 3) is unclear and needs further research.

The finding of better outcomes for this subgroup could be due to selection bias, or they may have received other treatments or services during study period, or they may have avoided hospitalisations due to legal reasons or other reasons. Another explanation for this strong association with the *low-to zero* trajectory may be that the justice-involved subgroup generally has a legal requirement of completing AOD treatment (otherwise they would need to face legal consequences) which could have worked as a motivator for this group to attend the program and achieve positive results (Alemi et al., 1995; Fletcher & Grella, 2001). While a number of studies show an association of greater AOD-use with crime among young people (Australian Institute of Health and Welfare, 2018c; Bennett et al., 2008), existing knowledge on the relationship between crime and AOD-use and other outcomes among adolescents treated in residential AOD treatment is limited. Recently, Whitten et al. (2022) found that, among adolescents with a prior criminal conviction, PALM treatment completion was associated with a significantly lower rate of hospitalisation for all diagnosis categories including substance use disorder and mental health problems, compared with non-completion group, which is consistent with the findings of the current study although the authors did not include non-attend group as a comparison in their analysis.

Recent research focussed on markers of social disadvantage, such as homelessness, family troubles, lack of engagement in education and/or employment, and influence of peers with AOD issues were shown to be associated with increasing contact of young people with the youth justice system and involvement in problematic AOD use (Green et al., 2016; Nathan et al., 2020; Whitten et al., 2022). The holistic approach of PALM treatment which addresses family issues and a young person's general life issues may have helped change these young people's engagement in crime and AOD use behaviour. and translated to lower hospitalisations among justice-involved participants in the current study. However, there may be other possible explanations, apart from the PALM treatment effects. As shown by the results from the trajectory analyses, participants in the lower hospitalisation trajectories in both studies were likely to be younger at referral, not identify as -Aboriginal, have lower levels of mental health problems and stable living, which may indicate that justice-involved participants in this trajectory may have less severe pre-treatment problems requiring less or no hospitalisations over time. However, to confirm this, further investigation examining interaction of justice-involved with these characteristics are required to identify the factors that moderate the effects of being justice-involved on outcomes. However, this is beyond the scope and objective of this study, and therefore it needs further research. Another possible explanation may be that justice-involved participants may not have access to hospitals or other health services while in the justice system, and this lack of access may have then been reflected in their hospitalisation trajectories (*low-to-zero*).

7.2.4 Finding 4 - Aboriginal participants had poorer outcomes

The results from all three studies in this thesis showed that Aboriginal participants experienced poorer outcomes following treatment including higher mortality rates, higher AOD- and MH-hospitalisation rates than non-Aboriginal participants. In the trajectory analysis, Aboriginal participants were significantly more likely to be classified in both higher trajectories (*high-decreasing/chronic-high* and *increasing* classes) of AOD- and MH-hospitalisations, compared with *low-to-zero* class. These poorer outcomes among young Aboriginal participants may be linked to well-established evidence from prior research that young Aboriginal Australians face a multitude of challenges associated with the cumulative effects of historical trauma and social disadvantages including racial discrimination, homelessness, less access to health and other services, less employment opportunities, and family issues (Australian Institute of Health and Welfare, 2018a; Catto & Thomson, 2008; Gray et al., 2018). National data shows Aboriginal Australians experience higher rates of mental health problems than non-Indigenous people, with 2 in 5 young Aboriginal Australians aged 15-24 reporting long-term mental health issues, mainly anxiety disorders, depressive disorders, behavioural or emotional problems and harmful drug or alcohol use or dependence (Australian Institute of Health and Welfare, 2018a). In the current study, 43% of the PALM participants were young Aboriginal Australians, compared to <3% in the general population, and over a third (>34%) of Aboriginal participants had pre-existing experiences of attempting suicide and/or self-harm. Self-harm and suicide rates among Aboriginal and/or Torres Strait Islander population, particularly amongst young people (<25 years), are among the highest in the world (Dudgeon et al., 2016; Nathan et al., 2020).

Supporting the findings of the current study, a recent study of PALM participants has reported that Aboriginal young people attending PALM residential treatment for AOD use are 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 (Nathan et al., 2020). PALM's Therapeutic Community offers a holistic and multidimensional approach to treatment. However, the findings of the current study raise a question about whether Aboriginal young participants, particularly those with greater pre-treatment comorbid psychological distress, are receiving a therapeutically and culturally appropriate treatment in the PALM residential treatment setting (Hill et al., 2022), where adolescents with different levels of need and experiences are present in the same setting. Therefore, the findings from the current study merit attention as well as previous findings that highlight the need for effective and culturally targeted interventions (Hill et al., 2022; Nathan et al., 2020). Intervention at the individual and societal level to address the underlying

multidimensional complexities related to socio-economic and historical factors among Aboriginal participants and problematic drug and alcohol use remain an important objective for residential treatment programs and policy makers (Nathan et al., 2020).

7.2.5 Finding 5: Females were more likely to have poorer outcomes than males

The results from all three studies for Aim 1- Aim 3 showed that female participants had poorer outcomes, with significantly higher mortality rates, AOD- and MH-hospitalisation rates than that for males. Interestingly, when stratified by psychological distress, females who had lower psychological distress (GSI<63) showed higher mortality rates than females with greater psychological distress (GSI≥63) and significantly higher than males from both mental health categories (GSI<63, GSI≥63). A similar result was obtained from trajectory analysis in Study 2, which showed that females who had lower psychological distress (GSI<63) were significantly more likely to be in *increasing* AOD-hospitalisation trajectory indicating that females with less mental health problems were more likely to demonstrate more severe AOD use behaviour as they transitioned from adolescence to young adulthood to adulthood. However, MH-hospitalisations were not significantly different for female and male participants in the MH-hospitalisation trajectories detailed in study for Aim 3, however, the odds were greater for females than males (although not statistically significant) being in the *chronic-high* MH-hospitalisation trajectory where participants with greater mental health problems were more likely to be classified, compared to the low-to-zero trajectory class.

An explanation for the findings of poorer outcomes for females in all three studies, particularly poorer mortality and AOD-hospitalisations outcomes, despite having lower mental distress, could be due to a larger proportion of females (than males) in the current study being poly-drug users and having greater substance use dependence (score >5) at referral, having greater experience of suicidal attempts or self-harm, physical or sexual or verbal assaults. This is supported by the finding of an Australian study of female participants in PALM treatment, which found that young females using drugs (methamphetamines) are likely to also be poly-drug users, in unstable living arrangements, have a history of trauma and problematic family situations (Dixson et al., 2018). Further, another Australian study found that young women attending AOD-programs experienced higher rates of psychosocial problems including mental health problems, trauma, sexual abuse, self-injury, suicide attempts, and homelessness, than their male counterparts (Mitchell et al., 2016). The findings of these studies may explain why females are more likely to use substances at greater levels and in more harmful ways than males, causing elevated hospitalisations, mortality and suicides post treatment, as found in the current study. These findings underscore the importance of meeting the

specific needs of females in residential programs, and highlight a need for further research on the relationship of their drug use to prior trauma and adverse experiences (Dixson et al., 2018).

7.2.6 Finding 6: Association of cannabis and opioids as drug of concern (DoC) at referral with poorer outcomes

In examining the association of type of principal DoC at referral with the outcomes, results from trajectory analyses in Study 2 and Study3 showed that, compared to *low-to-zero* class, those who were classified in the two higher trajectory groups of AOD-hospitalisations (*high-decreasing* and *increasing*) and MH-hospitalisations (*chronic-high* and *increasing*) were more likely to report, cannabis/hallucinogens/tranquiliser (collapsed as one category: 94% cannabis, 3% hallucinogens, and 3% tranquiliser) and opioids as principal DoC at referral, compared with those who reported alcohol as a principal DoC. An examination of drug types for causes of hospitalisations was not within the scope of this research. However, these findings suggest that heavy use of cannabis or other psychoactive drugs or opioids during adolescence were predictive of problematic drug use with likelihood of continuation of these drugs as well as associated mental health problems during late adolescence or young adulthood to adulthood requiring AOD- or MH-hospitalisations. Consistent with these findings, several past research studies on adults as well as adolescents provide evidence of associations of mental health disorders, mainly major depression and anxiety disorder, with opioids, cannabis, sedatives/hypnotics or poly-drugs use (Albertella & Norberg, 2012; Bartu et al., 2003; Burdzovic et al., 2015; Lawrence et al., 2015; Marel et al., 2019; Reichelt et al., 2019; Swift et al., 2008). Prior research reports that mental disorders are common among people hospitalised for opioid-related harms, mostly opioid-related poisonings and opioid use disorders (Australian Institute of Health and Welfare, 2018b; Queeneth et al., 2019). Heavy and daily cannabis use in young people has also been found to be strongly associated with pre-existing mental health problems (Lawrence et al., 2015; Marel et al., 2019), and persistent cannabis use co-occurring with mental health problems during adolescence is strongly predictive of later problematic cannabis use at young adulthood (Marel et al., 2019; Reichelt et al., 2019; Swift et al., 2008) as well as later cannabis related mental health problems (such as anxiety and depression) as they grow into adulthood (Scholes-Balog et al., 2013). These prior findings support the findings of the current study of higher AOD- and MH-hospitalisations among problematic cannabis and opioids using adolescents.

More importantly, the current study findings suggests that the effectiveness of PALM treatment was not evident for those who report using problematic cannabis/hallucinogens/tranquiliser or opioids at referral, demonstrating continued AOD-use and mental health problems from late adolescence to young adulthood and adulthood, compared to those who reported alcohol or other drugs as DoC at

referral. Therefore, these finding highlight the importance of better screening and tailored programs including longer continuing care for those using these substances at referral.

7.3 Strengths and Limitations

This study has several strengths making this it unique and offering a strong contribution to evidence base with currently limited literature. However, the findings should be considered in light of several limitations of this study. These strengths and limitations are discussed below.

7.3.1 Strengths

This study has addressed the existing gap in the literature in substance use treatment outcome research, particularly the outcomes of residential treatment with a Therapeutic Community (TC) approach, and extends the existing body of research in many ways. There is a growing body of empirical research on outcomes of several other AOD treatment programs, but residential TC approach has received a very little attention (Winters et al., 2018), despite adolescents in residential treatment having been found to have complex histories including trauma, comorbid psychiatric conditions, history of arrests, experience of sexual and physical abuse, and family histories of problematic AOD use (Dixson et al., 2018; Jainchill et al., 2005; Nathan, Bethmont, et al., 2016; Nathan et al., 2020; Neumann et al., 2010; Vourakis, 2005).

Most of the existing empirical research has evaluated short-term (up to one year or less) outcomes of substance use, health and psychological functioning of adolescents treated in residential program (Agosti & Levin, 2007; Albertella & Norberg, 2012; Dasinger et al., 2004; Godley et al., 2001; Gossop et al., 1999; Hambley et al., 2010; Hawke et al., 2000; Hser, Grella, et al., 2001; Jainchill et al., 2000; Morral et al., 2004). Apart from short follow-up (<12 months), there is a gap in knowledge about the effectiveness of residential AOD treatment for adolescents with poor methodological rigour of existing studies (Tripodi, 2009). In other words, there is a dearth of long-term residential outcome studies using large samples, strong comparison groups, and appropriate and robust study designs. The reasons for research examining young people's long-term outcomes beyond one year being relatively sparse include that participants are often followed-up prospectively, in most cases, using self-reported interviews, which has increasing risks of attrition, smaller sample size, risk of bias, and greater operational and time costs (Caruana et al., 2015; Gustavson et al., 2012). However, both AOD use disorder and mental health disorders are chronic conditions that may require these people to receive different amounts and types of health services over many years (Chi & Weisner, 2008; Hser, Hoffman, et al., 2001; McLellan, 2002), therefore long-term outcome research is important. Additionally, among very few extant long-term studies, the findings on treatment effectiveness have

been inconsistent, with some showing positive effects on substance use lasting beyond the first year (Brown et al., 2011; Whitten et al., 2022), and others showing erosion of positive effects on substance use, psychological functioning, and other outcomes after 12 months and no evidence of treatment effects in the long-term (Jainchill et al., 2005). These mixed findings among the existing literature underscore a need for more long-term and methodologically strong studies to evaluate long-term effectiveness of residential TC treatment for adolescents. Therefore, the current study addresses these gaps by using longitudinal linked data following up to 16 years post TC/referral for a sample of 3529 adolescents who were referred to PALM residential TC treatment program. There are several notable strengths of the current study.

First, the current study has used a relatively larger sample (n=3529 adolescents) from the treatment program and linked data allowed follow-up of everyone in the sample without attrition for a longer period up to 16 years post-PALM, compared to the extant long-term research on treatment outcomes of adolescents. Greater sample size means greater power to detect differences in effects across the groups. While most of the long-term studies included smaller samples, mostly with initial recruitments of less than 500 adolescents (Anderson et al., 2010; Brown et al., 2001; Campbell et al., 2016; Edelen et al., 2010; Myers et al., 2007; Sterling et al., 2009; Winters et al., 2007), only a few past works have utilised larger samples at recruitment (Chung et al., 2008; Jainchill et al., 2005; Larm et al., 2008; Whitten et al., 2022). However, most of these long-term studies suffered a substantial amount of attrition in the subsequent follow-ups due to study design using self-report.

Second, data on outcomes in the current study were collected by linking to administratively recorded data of the individuals in the sample, instead of self-reported data. Linked administrative data are more likely to be accurate because they are recorded as the outcomes unfold (Evans et al., 2010). Most of the short-term or long-term studies have used self-reported data, which are mostly based on recall. Past research also suggest that there is evidence of mood influences on memory, such that individuals who are depressed are more likely to remember negative or unpleasant events (Harris et al., 2008). Studies have shown that self-reported information about substance use cause underreporting in comparison with biological tests (Khalili et al., 2021), and inconsistencies in information reported by adolescents (Harris et al., 2008). Inaccurate reporting of substance use can cause measurement errors such as self-reported bias, and can bias measures of treatment outcomes and program performance (Harris et al., 2008; Khalili et al., 2021; Magura & Kang, 1996; Tripodi, 2009; Williams & Chang, 2000). Avoiding these drawbacks of self-reported data, the current study has used the linked administration data to follow all the participants recruited in the study after exiting from PALM for a longer period up to 16 years with no attrition. The principle advantage of

using administrative data is that it provides information of individuals allowing investigation of events, service system interactions, and outcomes as they unfold and influence one another over the long term without loss-to-follow-up (Evans et al., 2010). Although data linkage involves some ethical, legal, and practical limitations to its use, administrative data can provide information on individuals who may be characterized by unique experiences and need and who are hard to follow up using more traditional research methods (Evans et al., 2010).

Despite having several benefits of using administrative data to undertake research in AOD treatment outcomes of young people using data linkage has just begun in Australia (e.g., Bista et al., 2021; Whitten et al., 2022). The study reported in Chapter 3 (Bista et al., 2021) is the first mortality study, to our knowledge, of adolescents referred to a residential TC treatment in Australia and globally. The use of longitudinal linked administrative hospital admission data for AOD- and MH-hospitalisation latent trajectory analysis (GMM) is also novel in this field of study.

Third, the current study has included a PALM treatment non-attend group (those who were referred to PALM program but did not attend the program or left program within three days of attendance) as a comparison group to compare with treatment completion group (days>30) and non-completion group (days<=30), a major weakness of past research (Williams & Chang, 2000). Previous evidence from treatment outcome studies have suggested that a rigorous evaluation design needs to include not just a larger sample and longer-term follow-up with minimum loss to follow-up, but also an appropriate comparison group such as no-treatment group (Tripodi, 2009; Williams & Chang, 2000; Winters et al., 2018). However, there is a dearth of long-term studies providing comparison between treatment groups and no-treatment groups (Winters et al., 2007), although there are some long-term studies providing comparisons between main treatment types such as TC and non-TC (Edelen et al., 2010), between pre- and post-treatment outcomes from the same program (Jainchill et al., 2005), or between treatment completed and non-completed (Whitten et al., 2022). Williams and Chang (2000) suggest using 'no-treatment' as the comparison group to detect actual treatment effects, rather than comparing treatment completion with non-completion is optimal as the authors assert that treatment completers are more likely to be motivated to change than treatment dropouts, and therefore, motivation may be the reason for substance use improvement rather than the AOD treatment program.

Fourth, this study has taken advantage of a recently advanced analytical method of growth mixture modelling (GMM), a person-centred approach, (Asparouhov & Muthen, 2021; Asparouhov & Muthén, 2014; Muthén & Muthén, 2000) in the analysis of longitudinal data, which has allowed modelling heterogeneity in the data and identifying distinct subgroups in the sample, with each

subgroup showing a heterogenous trajectory pattern of AOD- and MH-hospitalisation outcomes over time from adolescence to adulthood. In AOD use and mental health research, there is a recognition of heterogeneity in developmental pathways, such as stages of progression in AOD involvement from adolescence to adulthood, or adolescent-limited versus life-course-persistent antisocial behaviour, etc., and person-centred approach (e.g., growth mixture models) takes unobserved heterogeneity into account (Muthén & Muthén, 2000). Additionally, there are several other advantages and strengths associated with growth mixture models. For example, Tomczyk et al. (2016) highlights that mixture models are not strongly influenced by distribution assumption, such as low cell frequencies or skewness, and beneficial particularly when studying substance use field as these variables are often highly skewed. Also, GMM allows for the assessment of initial status and change over time (variation around mean estimates) for different unobserved subpopulations of a sample. Noteworthy is that the identified patterns or subpopulations modelled in GMM are unobserved.

The current study used recently advanced manual three-step BCH method in GMM (Asparouhov & Muthen, 2021) that allowed estimating trajectory classes of outcomes without influence of any predictors or covariates, i.e., the trajectories were purely data-driven. In the next step, it estimated multinomial logistic regression, by accounting for classification errors estimated as weight for each participant, to determine baseline predictors of those trajectory classes. More importantly, this approach allowed using predictors or covariates in the predictive model even though they have missing values through multiple imputation provision within the BCH method. Therefore, the current study has been able to include several individual and contextual baseline predictors and covariates (such as treatment-attend groups, age at referral, sex, Indigenous status, pre-treatment substance dependence scores, mental health scores, involvement of youth justice system, drugs of concern, number places lived during last six months, etc.) simultaneously in the model to adjust for the potential confounding effects of covariates each other. Evidence on the factors associated with longitudinal patterns of AOD use or mental health problems from the extant studies on treatment outcomes of adolescents using person-centred trajectory analysis is limited. Although there is an emerging body of research using a person-centred approach in substance use, research using this approach identifying trajectories of AOD or mental health service utilisations post-residential treatment of young people is scarce. To our knowledge, this is the first study to investigate heterogenous trajectory patterns of AOD- and MH-hospitalisations of adolescents following residential TC program and baseline predictors of those trajectories.

7.3.2 Limitations:

Despite several strengths of this dissertation, the findings yielded in this study must be considered in the context of several limitations. First, due to a study design with a consecutive enrolment or referral of adolescents to the PALM program between 2001 and 2016, participants have different follow-up time periods post-PALM. For the analytical sample in this study, the participants referred/enrolled until 2015 were included but followed-up until 2016, providing a follow-up window of at least a year up to 16 years. Particularly, those who were referred to PALM for the first time during later periods after 2013 have smaller window of follow-up times, and therefore there is likely underreporting of the longer-term outcomes for this proportion of participants in this study.

Second, detailed data on participants from the 'non-attend' group among three treatment attending groups, who were referred but did not attend the PALM treatment, were not available for researchers, and therefore the reasons for not attending PALM could not be determined. However, information from staff about reasons people do not attend suggest that the main reasons for non-attending include: some of those who were involved in youth justice system may have been refused bail; or some may have lost interest in attending treatment before enrolment or within three days of enrolment not being eligible for the residential program due to not meeting DSM-IV substance abuse/dependence criteria (Dixson et al., 2018; Nathan, Rawstorne, et al., 2016). Therefore, this study could not determine if participants from the non-attend group had received treatment from other programs such as outpatient or short-term inpatient or another residential program after their referral to PALM. If these participants have received AOD treatment from other programs, the participants in this group may have improved outcomes over time which would impact differences in effects between treatment attending groups, compared with this non-attend group.

Third, although the data on outcomes were collected using data linkage in this thesis, baseline data collected from the participants referred to PALM program during assessment for eligibility for entry to the program were self-reported and some of them may have been based on recollection, particularly the data collected for AOD use types and severity, mental health problems, histories of criminal activities, etc. Therefore, the self-reported pre-treatment variables used for the analytical purposes in this thesis, such as DSM-IV substance dependence scores using DSM-IV questionnaires for substance abuse and substance dependence criteria, GSI T-scores using Brief Symptoms Inventories (BSI) questionnaire, and records on histories of involvement with crime and youth justice system, may be influenced by inaccuracies, inconsistencies, or underreporting or overreporting, which can cause self-reported bias and measurement errors (Harris et al., 2008; Khalili et al., 2021; Tripodi, 2009; Williams & Chang, 2000).

Fourth, data on several pre-program variables including pre-referral AOD use, mental health (GSI), involvement in justice system for 'non-attend' group were not recorded for the 2001-2009 period in the PALM baseline database, which may lead to some bias in our estimates, particularly in the relationship between outcomes and the pre-treatment baseline variables; however, the effect of this bias is unknown.

Fifth, for the mortality analysis, the cause of death data was available for only 50 of the 63 total deaths, which may lead to some bias in our estimates; however, the effect of this bias is unknown.

Sixth, due to the limitation of the linked data, it is unknown whether the participants with no AOD-or MH-hospitalisation records during the study period had been involved in AOD-use behaviours or had mental health problems post-PALM although they were not hospitalised for those causes or in another state or territory hospital outside NSW. As reported in the literature, the absence of records in the linked data are generally interpreted as a non-occurrence of an event (Evans et al., 2010), this thesis interpreted the absence of mortality, AOD- and MH-hospitalisation records as the non-occurrence of outcomes, which, in turn, was interpreted as positive outcomes. Also, the scope of this dissertation did not allow for using data linked to other services such as clinics, emergency or ambulatory services, therefore, this study could not determine whether the participants had used those services, other than inpatient hospitalisations, for their AOD-use or mental health problems during the study period, which may have underestimated the actual AOD-use and mental health problems of the participants over time post-PALM. Also, the participants who had zero hospitalisations (i.e., no records for hospitalisations) who were classified in the low hospitalisation trajectory class (low-to-zero) in both AOD- and MH-hospitalisation trajectory analyses, were interpreted as having positive outcomes of PALM program with low or no hospitalisations for AUD use or mental health problems over time from adolescent to young adulthood to adulthood, the actual treatment effect may be different, with likely to be overestimated in the current study.

Seventh, several different statistical strategies exist for examining longitudinal data of this type. Each strategy has its strengths and weaknesses (Bauer, 2007). In this dissertation, I used growth mixture modelling (GMM) for modelling longitudinal hospitalisation data. Using this approach, the best fitting model is selected as the optimal model based on both theory and statistical criteria; these decisions could be made differently on the basis of alternative theories. For example, I chose a model with fairly high entropy and posterior probabilities. This could suggest that the model has been closely fit to the data. Also, although entropy is not a measure of model fit for identifying an optimal class solution in growth mixture modelling (Muthén & Muthén, 2000), with the reported entropy value (<0.7) in both AOD- and MH-hospitalisation trajectory analyses, classification bias may

have occurred. However, averaged posterior probability of group membership value being >0.7 in two larger trajectory classes (low-to-zero and increasing) in both studies indicates greater classification precision. Also, classification error was taken into account by estimating weight for each induvial using BCH method in GMM and used those weights in the predictive models to examine significant predictors of those identified trajectories (Asparouhov & Muthen, 2021; Asparouhov & Muthén, 2014), however, a minimised level of classification error may have occurred.

7.4 Implications

7.4.1 Implications for service provider and policy makers:

While treatment for AOD using adolescents, particularly those with comorbid mental health problems and other related life problems, is challenging due to complex treatment needs, poor treatment engagement and retention, and a lack of sustainable treatment outcomes (Bender et al., 2006), this dissertation has brought some unique and key findings to the light. These findings can inform PALM and other residential treatment programs about different groups of young people with unique needs and inform service redesign and targeted interventions tailored to the characteristics of different high-risk groups. An important finding of this research is that post-PALM overall mortality rates, AOD-hospitalisation and MH-hospitalisations rates were substantially higher among young people referred to PALM during their adolescence, compared with the general community. Also, these rates were substantially higher for female participants, Aboriginal Australians, those older at referral, those who have higher pre-treatment psychological distress and unstable living, compared to their counterparts, suggesting that these demographic groups may have different and complex needs requiring targeted and specialised treatment interventions.

Another key finding showed that the overall mortality, AOD- and MH-hospitalisation rates were higher for both treatment attending groups, longer stay (days>30) and shorter stay (days $\leq$ 30), compared to no-treatment (non-attend) group, indicating that those who attended treatment, regardless of treatment completion or non-completion, have complex pre-treatment problems and adversities such as greater substance dependence, and comorbid mental health problems that require tailored, culturally effective and person-centred treatment interventions.

Further, trajectory analyses in Study 2 and Study 3 of this thesis have provided key insights into heterogeneity in post-referral/program outcomes over time by identifying different subgroups, with some demonstrating positive outcomes, but others showing persistent or increasing poor outcomes in the long-term. These results provided evidence of heterogeneity in AOD-hospitalisation and MH-hospitalisation trajectories during transitioning from adolescence to young adulthood and

adulthood, with around two thirds of the sample demonstrating low AOD- and MH hospitalisation trajectories, mainly those who were younger, non-Aboriginal participants, who had less severe pre-treatment mental health and living problems, and those who were involved with the justice system. This finding suggest that PALM residential treatment has been more effective for those with less severe pre-treatment problems including those referred by justice system. While the explanation for the positive outcomes shown by those involved with justice system is unclear and needs further research, this finding may indicate that they have enhanced motivation to avoid legal consequences supported by past studies (Alemi et al., 1995; Fletcher & Grella, 2001). Therefore, although the explanation is unclear, this finding provides strong support for residential programs for young people referred by the justice system based on the positive outcomes demonstrated in this group in the current study.

An important implication of this research is that the trajectory analyses provided evidence that the post-referral/program outcomes were worsened for around one third of the sample, mainly for females, young Aboriginal Australians, those with greater pre-treatment mental health problems, unstable living, and those who reported opioids and cannabis/hallucinogens as their principal drugs of concern at referral, who were found to have persistent high or increasing AOD- and MH-hospitalisation trajectories over time from adolescence in to adulthood. The participants with these characteristics classified in these two higher trajectory classes were identified as the high-risk subgroups from the current study. This finding highlights the importance of better screening at referral to identify those at high-risk of poorer long-term outcomes so that the treatment and supports including continuing care can be tailored to their needs.

Lastly, the finding of the *increasing* trajectory class in both AOH- and MH-hospitalisation trajectory analyses have important implications. Over a quarter of adolescents of the sample who were classified in this *increasing* trajectory in both studies showed initial positive outcomes with very low hospitalisations in the first two years post-PALM and then their hospitalisations (both AOD-, and MH-hospitalisations) gradually increased over time during their transition from late adolescence through to young adulthood to adulthood. This finding indicates that there is a subgroup of young people who accelerate their AOD use behaviours during emerging adulthood and continue until adulthood, requiring increased hospitalisations for AOD use as well as related mental health problems. This finding highlights not just identifying this subgroup at early stage of treatment, but also has important implications for longer and effective continuing care which is vital to retain the early positive treatment effects gained during adolescence over the long-term. The current continuing care policy of PALM, which provides continuing care for up to 3 years for those who

attended PALM residential treatment, must be extended to all participants who attended the program for longer period of at least 5 years post-PALM. Further research is also needed for possible inclusion of all participants which will ensure continuing services to those who could not stay in the treatment program, likely due to mental health and related life problems. For young people with high severity mental health problems, models of care that integrate AOD treatment with specialist psychiatric and psychological services should be trialled and evaluated (Campbell et al., 2016; Edelen et al., 2010) .

7.4.2 Implications for future research:

This study found that young people who were involved with the justice system were more likely to demonstrate improved outcomes, with lower rates of mortality, AOD- and MH-hospitalisations, as well as being classified in low-to-zero AOD- and MH-hospitalisation trajectories. However, explanations for this finding of justice-involved participants showing positive outcomes were unclear. Therefore, further research is needed to explore whether the positive outcome shown by the justice-involved participants are associated with the PALM treatment itself, or whether there are other mediating or moderating factors such as motivation and engagement in treatment, which may have altered the relationship between justice-involved young people and treatment outcomes. It is also important to investigate whether the low AOD- and MH-hospitalisations shown by justice-involved participants were due to lack of access to hospital services because of being under justice system supervision or incarceration.

The findings of poorer outcomes for young Aboriginal Australians and those with greater pre-treatment mental health problems highlight the need for further investigation about whether one AOD program in the same treatment setting has adequately addressed the different treatment needs of diverse participants referred for treatment. More importantly, research is needed to understand whether the current model of care is adequate to address AOD use problems and mental health comorbidity as well as the complex issues of Aboriginal young people who attend the program, because higher comorbid mental health and other problems may need more tailored or intensive treatment programs that are not in the current AOD-focussed program. Simultaneously, there is a need to build an evidence-based for integrated interventions that could be more effective for these groups of young people.

In the current study, I have investigated post-PALM long-term patterns of AOD use behaviours and mental health problems from a developmental perspective using hospitalisation longitudinal data. However, investigation of trajectories of co-occurrence of AOD-hospitalisations and MH-hospitalisations simultaneously over time was beyond the scope of the current research. This is an

area for future research supporting a developmental perspective which may examine the heterogenous patterns of co-occurrence of these problems or how mental health problems and substance use interact at different ages as adolescents transition to adulthood. This could be done by using parallel-process latent mixture modelling approaches and examine the factors associated with these varied patterns of co-occurrence. Also, the patterns of drug use types as well as mental health diagnosis types in the trajectories of hospitalisations over time could be another area of research using latent class analysis (LCA) approach.

In the current research, pre-treatment individual and contextual background variables differentially predicted membership into the differing AOD- and MH-hospitalisation trajectories. These findings highlight the need for examination of additional pre-treatment variables from childhood that may further clarify the unique antecedents of these patterns of AOD use, mental health and other outcomes.

7.5 Conclusion

This dissertation evaluated the effectiveness of a residential TC program (PALM) for adolescents (13-18 years) with AOD use problems by investigating mortality, AOD related hospitalisation, and mental health hospitalisation outcomes of adolescents referred to PALM in three separate analysis using longitudinal linked data following up to 16 years post-PALM. The specific aims were to determine the rates of mortality, AOD hospitalisations, and mental health hospitalisations, and identify trajectories of AOD hospitalisations and mental health hospitalisations and their predictors. These analyses have found elevated overall rates of mortality, AOD related hospitalisations, and mental health related hospitalisations among young people referred to PALM treatment during their adolescence, compared to the general population, with increased risks among female participants, young Aboriginal Australians, treatment-attending group, and those having greater pre-treatment psychiatric comorbidity and adversities. Drug overdose, mainly opioids, and suicide were the main causes of death among the participants.

Using growth mixture modelling, the findings of this thesis provided evidence of heterogeneity in the post-referral/program outcomes over time, which was reflected by identifying heterogenous patterns of AOD-hospitalisations as well as MH-hospitalisation trajectories following referral/program in separate analyses. More importantly, pre-program individual and contextual background variables differentially predicted membership into the patterns of hospitalisations across both AOD-hospitalisations and MH-hospitalisations. Both trajectory analyses showed that most of the participants (around two-thirds) in the cohort, mainly younger participants at referral,

non-Aboriginal participants, those with lower pre-treatment comorbid mental health problems, and those referred by the justice system, were more likely to be classified in the low trajectory class (*low-to-zero*) of AOD-hospitalisations and MH-hospitalisations trajectory post-program, indicating that improvement in AOD use and mental health outcomes after referral/program for this subgroup, particularly for those who were referred by youth justice system. However, this finding also identifies a need for further research for some explanations for these associations in particular for the justice system involved participants with improved outcomes. Nonetheless, this finding lends support for residential TC programs for justice system involved participants.

However, the positive outcomes were not evident for one-third of the cohort, who exhibited higher AOD- and MH-hospitalisation trajectories over time, mainly by older participants at referral, females, Aboriginal Australians, those with greater severity of pre-treatment comorbid mental health problems and unstable living last six months, and those who reported opioids and cannabis as drug of concern at referral. This finding highlights the importance of early screening to identify high-risk groups, and targeted, appropriate evidence-based and culturally safe integrated interventions including longer and tailored continuing care particularly for those with co-occurring mental health problems and young Aboriginal Australians. Further research is needed to evaluate the extent to which one AOD-program can address comorbidity and the range of needs among the diversity of young people referred.

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Supplementary Appendices

Appendix 1: ICD-10 diagnosis codes for AOD hospitalisations

Table S1: ICD-10 diagnosis codes for alcohol- and drug-related hospitalisations

AOD-hospitalisations	ICD-10 codes
Alcohol-related	E24.4; F10, F10.0-F10.9; G31.2; G62.1; G72.1; I42.6; K29.2; K70, K70.0 –K70.4, K70.9; K85.2, K86.0; O35.4; P04.3; Q860; R78.0; T51, T51.0, T51.1, T51.8, T51.9; X45; X65; Y15; Y90 –Y91; Z72.1
Drug-related	F11–16, F18, F19; O35.5; R78.1-R78.4, R78.6; T40–T50; T51, T52, T53; X40, X41, X42, X43, X44, X46, X47; X60, X61, X63, X64, X67; Y10, Y10, Y11, Y12, Y13, Y14, Y16, Y17; Z72.2

Source: Turning Point (2017).

Appendix 2: Description of covariates

Descriptions of covariates:

***Global severity index (GSI) T-scores*:**

To create a GSI T-score variable, initially, the total raw scores were calculated using 53-items of Brief Symptoms Inventory (BSI) (Derogatis, 1993), which was administered to assess comorbid psychiatric problems distressing/bothering client during last seven days including day of assessment. Then, these raw scores were converted to age-standardised T-scores using Standard T-score Norms for males and females. These T-scores were dichotomised using 63 as a cut-off score to consider psychological distress as clinical (GSI T-score <63 =0 and GSI T-score ≥63 =1) (Derogatis, 1993).

***DSM-IV Substance Abuse and Substance Dependence criteria*:**

Substance dependence score was calculated using DSM-IV Substance Dependence criteria (7-items) for any drug or alcohol use over the past 12 months and score of 3 or greater is considered as substance dependent (Table S2). DSM-IV Substance Abuse, which includes 4 criteria, requires the endorsement of one or more of these four symptoms (at any time) and no history of substance dependence for that category of substances (Abuse & Administration, 2016). At PALM, both DSM-IV substance abuse and dependence assessment criteria were used, however, PALM baseline data provided the substance dependence scores only for the analysis.

Table S2: DSM-IV *Substance Abuse* and *Substance Dependence* criteria for assessment

DSM-IV Substance Use Disorder Assessment	Symptoms
***Substance Abuse* criteria** **(One or more of four symptoms, at any time)**	1. Recurrent substance-related legal problems 2. Recurrent substance use in situations where it is physically hazardous 3. Recurrent substance use resulting in a failure to fulfill major role obligations at work, school, or home 4. Continued substance use despite having persistent or recurrent social or interpersonal problems caused or exacerbated by the effects of the substance
***Substance Dependence* criteria** **(Three or more of seven symptoms in the same 12-month period (or one symptom if dependence criteria have been met previously in the lifetime)**	5. Substance is taken in larger amounts or over a longer period than was intended 6. There is a persistent desire or unsuccessful efforts to cut down or control substance use 7. A great deal of time is spent in activities necessary to obtain the substance, use the substance, or recover from its effects 8. Important social, occupational, or recreational activities are given up or reduced because of substance use 9. Substance use is continued despite knowledge of having a persistent or recurrent physical or psychological problem that is likely to have been caused or exacerbated by substance use 10. Tolerance, as defined by either: (1) a need for markedly increased amounts of substance to achieve intoxication or desired effect or (2) a markedly diminished effect with continued use of the same amount of the substance 11. Withdrawal, as manifested by either: (1) the characteristic withdrawal syndrome for the substance (excludes Cannabis, Hallucinogens, and Inhalants) (2) the substance (or a similar substance) is taken to relieve or avoid withdrawal symptoms

***Principal drug of concern (DoC)*:**

The variable for principle drug of concern (DoC) included several categories for different types of drugs in the data, therefore, those drug categories were collapsed into four groups (1= opioids; 2=cannabis, hallucinogens and tranquilisers; 3= alcohol; 4=amphetamines, ERD, cocaine, and

inhalants) based on the similar drug effect types, although some drugs affect the body in many ways and can fall into more than one category (https://www.health.gov.au/health-topics/drugs/about-drugs/types-of-drugs). In the cannabis/hallucinogens/tranquilizer group, the majority were cannabis users (94%) along with 3% hallucinogens and 3% tranquiliser users. In amphetamine/ERD/cocaine/inhalants group, 56% amphetamines users, 39% ERD, 3% cocaine and 2% inhalant users. For the category 'opioids' as DoC, the data provided combined opioids, although the definition of 'opioids' includes heroin, methadone, opiate-based analgesics including codeine, morphine and oxycodone, and synthetic opioid drugs such as fentanyl.

Appendix 3: GMM and model selection criteria

Identifying trajectory classes using growth mixture model (GMM)

Before conducting GMM (a semi-parametric, group-based approach which allows differences in growth parameters across the latent classes providing separate growth models for each class (Muthén & Muthén, 2000), a series of unconditional latent class growth analysis (LCGA) were performed for up to 5 classes to examine trajectory classes and shapes using linear and quadratic growth models (Jung & Wickrama, 2008). LCGA, a special type of GMM, assumes no within-class heterogeneity, i.e., the variance-covariance estimates for the growth factors (intercept and slope) within each class are constrained to be zero (Nagin, 1999). LCGA suggested a 4-class quadratic model as the optimal model.

After examining LCGA models, a series of quadratic GMM for up to 4-class solutions was performed. The optimal class solution of GMM was identified after performing one- to four-class unconditional quadratic models allowing variances of intercept growth factor and residual variances to vary across classes, but the slope growth factor variance was fixed at zero due to convergence problem. To avoid local maximisation and convergence problem, 1000 random starting values were used for each model.

When allowing both intercept and growth factors to vary across classes, there were model convergence problems. Therefore, the variances of slope factors were fixed at zero. In all LCGA and GMM analyses, counts of AOD-hospitalisations were modelled using negative binomial distribution. The maximum likelihood estimator with robust standard errors (MLR) was employed, which is appropriate to handle non-normal and count data (Muthén & Muthén, 2010).

Model Selection

A number of model fit criteria were used to evaluate model selection: the Log Likelihood value (LL), the Bayesian Information Criterion (BIC), the sample adjusted Bayesian Information Criterion (SA-BIC), the adjusted Lo-Mendell-Rubin likelihood ratio test (LMR), and the Vuong-Lo-Mendell Rubin likelihood ratio test (VLMR). Smaller values of BIC, SABIC, and AIC indicate better fit (Little, 2013). For the LMR and VLMR, a p-value <0.05 indicates better fit for that class solution (k) compared to the previous class solution (k-1). Bootstrap likelihood ratio test (BLRT) was performed for the potential models only. A p-value <0.05 in BLRT indicate better fit for that class solution (k) compared to the previous class solution (k-1). As entropy was not a measure of model fit, it was not used to select a

class solution. For the class selection, we also gave an emphasis on the size of the classes, quality of the classification which was determined by using class-specific average posterior probability of assignment (APPA), and the interpretability of the classes. The APPA close to 1 (ideally >0.7) is indicative of a good fit and greater precision of the members' assignment in the classes (Blaze, 2013; Nagin, 2005; VanDerNest et al., 2020).

Multinomial logistic regression

A manual three step BCH method (Asparouhov & Muthen, 2021; Asparouhov & Muthén, 2014) was applied to examine the predictors of the latent class variable (trajectory classes) using multinomial logistic regression. In this three step BCH method, an unconditional latent class model in step 1 was performed and saved all the auxiliary variables (covariates) in the training data by avoiding the influence of these variables on the latent classes. The BCH weights were saved in step 2, which take into account the classification error of the latent class variable. Before performing logistic regression in step 3, multiple imputations in the predicting variables were performed to deal with messing values in predictors (details are in the next section below). In step three, multinomial logistic regression was performed using BCH weights to determine the predictors of the latent trajectory classes (i.e., latent class variable).

Missing data

Missing data in the outcome variable (AOD-hospitalisations) due to a consecutive enrolment study design was considered as a MAR (missing at random) and taken into account using the full information maximum likelihood (FIML) with robust standard errors estimation approach (Enders, 2010).

Missing data in predictors of latent class variable was handled by using multiple imputation using BCH method implemented in Mplus was used to deal with following the approach provided by Asparouhov and Muthen (2021) to maximise the sample size and reduce the selection bias. With this approach, we used the BCH weights saved in the first step of BCH method (i.e., growth mixture model) along with other covariates. BCH weights reduce bias by providing information on correlations between covariates and the latent class variable in the imputation process.

Before proceeding this multiple imputation process, we tested an assumption of this process if the missingness in predictors are MAR, i.e., if the missingness in predictors depend on the covariates used in the model, by using logistic regression of missingness in each predictor on the covariates with full data (i.e., sex at birth, age at referral, Australian Aboriginal identity, and treatment

program-attend variables). These results showed that the missingness was predicted by Australian Aboriginal identity ($p<.0001$) for all predictors and therefore it is presumed a MAR.

Appendix 4: Identifying optimal class GMM

We performed GMMs with varied number of classes from 2-class model up-to 4-class model. BIC increased as the number of classes increased. Among the models performed, 2-class and 3-class models had lower model fit values (BIC: 17488 and 17492 respectively), and 2-class model had greater average posterior probabilities (>0.7, i.e., cut-off value) for both classes. In addition to better model fit criteria, we further considered substantive importance of the classes, and selected the three-class GMM as the optimal class solution. In this 3-class model, the smallest sized trajectory class had a substantially higher estimated mean AOD-hospitalisation at each time point than other two trajectories, reflecting a high-risk group and therefore important to be examined although the size of this class was <5% with slightly lower average posterior probability of 0.63 (<0.7). The other two classes had average posterior probability of 0.74 and 0.80.

In this 3-class GMM, the largest class contained 68.0% (n = 2276) of the sample, with a low estimated initial mean AOD-hospitalisation (0.35) at 2-year follow-up and desisting by 8-year and afterwards ('*low-to-zero*' group). The second large class contained 29.2% (n=978) participants with a low initial estimated mean AOD-hospitalisations (0.37) but consistently increasing over time ('*increasing*' group). The third and the smallest class had 2.7% (n=92) participants, characterised by very high initial mean AOD-hospitalisations (2.21) with rates gradually declining over time ('*high-decreasing*' group), however mean AOD-hospitalisations were substantially greater than other classes throughout the study period.

Appendix 5: Additional results from multinomial logistic regressions

Table S3: Multinomial logistic regression (without interaction terms) comparing trajectories with each other (not with the reference class)

Characteristics	High-decreasing vs. Low-to-zero		Increasing vs. Low-to-zero		Low-to-zero vs. Increasing		Low-to-zero vs. High-decreasing		Increasing vs. High-decreasing	
	Adjusted OR [95% CI]	*P*	Adjusted OR [95% CI]	*P*	Adjusted OR [95% CI]	*P*	Adjusted OR [95% CI]	*P*	Adjusted OR [95% CI]	*P*
Referral age at 13	1.50 [0.90-2.50]	0.125	**1.24 [1.01-1.52]**	**0.037**	**0.81 [0.66-0.99]**	**0.037**	0.67 [0.40-1.12]	0.125	0.83 [0.47-1.46]	0.518
Indigenous status:										
Aboriginal (vs Non-Aboriginal)	**8.37 [2.74-25.54]**	**<0.001**	**4.28 [2.57-7.13]**	**<0.001**	**0.23 [0.14-0.39]**	**<0.001**	**0.12 [0.04-0.36]**	**<0.001**	0.51 [0.15-1.71]	0.275
Gender:										
Female (vs Male)	1.62 [0.56-4.67]	0.373	**1.78 [1.08-2.93]**	**0.024**	**0.56 [0.34-0.93]**	**0.024**	0.62 [0.21-1.78]	0.373	1.1 [0.34-3.54]	0.875
Treatment:										
Days≤30 (vs Non-attend)	1.80 [0.41-7.94]	0.44	0.79 [0.45-1.38]	0.407	1.23 [0.72-2.23]	0.407	0.56 [0.13-2.46]	0.44	0.44 [0.09-2.21]	0.318
Days>30 (vs Non-attend)	1.42 [0.33-6.03]	0.473	0.76 [0.46-1.24]	0.271	1.32 [0.80-2.17]	0.271	0.71 [0.17-3.0]	0.636	0.53 [0.11-2.55]	0.431
Court/police involvement at referral:										
Justice-involved: Yes (vs No)	0.30 [0.08-1.08]	0.650	**0.44 [0.26-0.75]**	**0.002**	**2.29 [1.34-3.89]**	**0.002**	3.36 [0.93-12.2]	0.065	1.47 [0.35-6.16]	0.597
Global Severity Index T-score:										
GSI≥63 (vs GSI<63)	**4.37 [1.32-14.49]**	**0.016**	1.59 [0.88-2.85]	0.124	0.63 [0.35-1.14]	**0.124**	**0.23 [0.07-0.76]**	**0.016**	0.36 [0.1-1.36]	0.132
Substance Dependence										
score >5 (vs score <5)	0.81 [0.27-2.40]	0.699	1.34 [0.81-2.21]	0.252	0.75 [0.45-1.23]	0.252	1.24 [0.42-3.68]	0.699	1.66 [0.49-5.63]	0.415
Drug of concern at referral										
Opioids (vs alcohol)	**11.33 [1.03-124.9]**	**0.047**	**19.48 [2.68-141.7]**	**0.003**	**0.05 [0.01-0.37]**	**0.003**	**0.09 [0.01-0.97]**	**0.047**	1.72 [0.22-13.75]	0.609
Cannabis/hallucinogens/tranq (vs alcohol)	**4.63 [1.32-16.22]**	**0.016**	**3.57 [1.83-6.99]**	**<0.001**	**0.28 [0.14-0.55]**	**<0.001**	**0.22 [0.06-0.76]**	**0.016**	0.77 [0.18-3.24]	0.723
Amph/ERD/cocaine/inhalants (vs alcohol)	0.35 [0.02-6.91]	0.490	1.32 [0.73-2.37]	0.358	0.76 [0.42-1.37]	0.358	2.86 [0.15-56.37]	0.490	3.76 [0.17-85.28]	0.405

* Tranq=tranquiliser; Amph=amphetamine; ERD=ecstasy related drugs

Table S4: Multinomial logistic regression (without interaction terms) comparing *Low-to-zero* trajectory with other two trajectories (Ref DoC: opioids as drug of concern (DoC))

Characteristics	Low-to-zero vs. Increasing		Low-to-zero vs. High-decreasing	
	Adjusted OR [95% CI]	*P*	Adjusted OR [95% CI]	*P*
Referral age at 13	**0.80 [0.66-0.98]**	**0.033**	0.67 [0.40-1.11]	0.121
Indigenous status:				
Aboriginal (vs Non-Aboriginal)	**0.23 [0.14-0.39]**	**<0.001**	**0.12 [0.04-0.37]**	**<0.001**
Gender:				
Female (vs Male)	**0.55 [0.34-0.90]**	**0.017**	0.62 [0.21-1.78]	0.365
Treatment:				
Days≤30 (vs Non-attend)	1.22 [0.70-2.12]	0.485	0.53 [0.12-2.39]	0.411
Days>30 (vs Non-attend)	1.29 [0.79-2.11]	0.316	0.69 [0.16-2.30]	0.612
Court/police involvement at referral:				
Justice-involved: Yes (vs No)	**2.38 [1.40-4.05]**	**0.001**	3.47 [0.96-12.56]	0.058
Global Severity Index (GSI) T-score:				
GSI≥63 (vs GSI<63)	0.66 [0.37-1.19]	0.166	**0.24 [0.07-0.79]**	**0.019**
Substance Dependence				
score >5 (vs score <5)	0.72 [0.44-1.19]	0.196	1.21 [0.41-3.59]	0.731
Drug of concern at referral				
Cannabis/hallucinogens/tranq (vs opioids)	1.56 [0.50-4.89]	0.442	0.74 [0.10-5.29]	0.766
Alcohol (vs opioids)	**6.95 [2.19-22.04]**	**0.001**	3.82 [0.48-30.36]	0.205
Amph/ERD/cocaine/inhalants (vs opioids)	**4.22 [1.38-12.88]**	**0.011**	9.81 [0.35-275.40]	0.180

* Tranq=tranquiliser; Amph=amphetamine; ERD=ecstasy related drugs

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