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Emergency department visits and hospital admissions for injury in children who participated in the Brighter Futures program: a population-based data linkage study

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LIST OF ABBREVIATIONS

AEDC	Australian Early Development Census
APDC	Admitted Patients Data Collection
ATE	Average Treatment Effect
ATT	Average Treatment effect on the Treated
EDDC	Emergency Department Data Collection
FACS	Department of Family and Community Services
ICD	International Classification of Diseases
IPTW	Inverse Probability of Treatment Weights
KIDS	Key Information Directory System
NHMRC	National Health and Medical Research Council
NSW	New South Wales
OOHC	Out of Home Care
PDC	Perinatal Data Collection
RBDM	Register of Births, Deaths and Marriages
RCT	Randomised Controlled Trial
ROSH	Risk of Significant Harm
SNOMED	Systematized Nomenclature of Medicine

EXECUTUVE SUMMARY

Background

Injuries are a leading cause of child morbidity and mortality in Australia. Early childhood and home visiting programs offer one way to support vulnerable families and improve child outcomes, including prevention of child injuries. One such program is the Brighter Futures program that was rolled out in NSW in 2003/04 to support families to prevent them from escalating in the child protection system.

This study had three main objectives. The first objective was to characterise children and families who were offered involvement in the Brighter Futures program, and those who went on to participate in the program. The second objective was to quantify the burden of serious injury experienced by Brighter Futures children, and to compare injury outcomes with the same-age general population of children in NSW during the study period. The third objective was to examine the potential to apply quasi-experimental methods to linked cross-sectoral population data to assess the impact of the Brighter Futures program on early childhood outcomes.

Methods

The study population was derived from the Seeding Success study data resource, which includes linked, cross-sectoral population data from health, education and community services for a cohort of children who were born in NSW, and who started school and have an Australian Early Development Census (AEDC) record in 2009 or 2012. We restricted the study population for this report to the 80,952 children who started school in 2012 because complete program data were not available from birth for the 2009 school starters. Of children in the 2012 school starter cohort, 3,193 children had contact with the Brighter Futures program, 2152 children went on to participate in the program and 68,242 children had no known contact with the child protection system before starting school. The exposures under investigation were the initial period of engagement with Brighter Futures when families/services considered suitability for program participation, and Brighter Futures program participation. The study outcome was emergency department visit and or hospital admission for injury. Rates of injuries were calculated as the number of emergency department visits and hospital admissions per person years at risk. Differences in emergency department visits and hospital admissions for injury between children of families who were engaged and/or participated in the program and children who had no known contact with the child protection system during the study period were calculated as rate differences and rate ratios. For the quasi-experimental scoping analysis, propensity score matching methods were used to identify the best possible comparison group for Brighter Futures children from the population data resource. Logistic regression models were used to compare early childhood outcomes between Brighter Futures children and the comparison group.

Results

A higher percentage of children whose families were engaged and/or participated in the Brighter Futures program were Aboriginal, had low birth weight, were born prematurely, had special needs and lived in remote and disadvantaged areas compared with children with no known contact with the child protection system during the study period. The mothers of Brighter Futures children were younger, fewer were married and more smoked during pregnancy compared with mothers of children with no known contact with the child protection system during the study period.

Between birth and the end of their first year of school, 47% (n=1,501) of children whose families were engaged and/or participated in the program had a total of 2,727 injury-related emergency department visits and/or hospital admissions. The majority of these were treated in the

emergency department only (85.5%) and 14.5% were treated in the hospital.

Rates of injury-related emergency department visits and/or hospital admissions ranged from 82 per 1,000 person years (95% CI 72-93) to 169 per 1,000 person years (95% CI 155-184) across 1-year age groups between birth and six years of age in children whose families were engaged and/or participated in Brighter Futures. Rates of injury-related emergency department visits and/or hospital admissions peaked when children were two years old and were lowest in their first year of life. Rates of injury related emergency department visits and/or hospital admissions were higher among children whose families were engaged and/or participated in the program compared with children with no known contact with the child protection system during the study period. For each year of age between birth and six years, the rate difference for injury-related emergency department visits and/or hospital admissions between children whose families were engaged and/or participated in the program and children with no known contact with the child protection system ranged from 42 per 1,000 person years (95% CI 30-56) to 64 per 1,000 person years (95% CI 49-82). The rate ratio of injury-related emergency department visits and/or hospital admissions between children whose families were engaged and/or participated in the program and children with no known contact with the child protection system ranged from 1.5 to 2.0 across the age range. There was no clear pattern of injury-related emergency department visits and/or hospital admissions in relation to the child's age when the family first participated in the program, which may have been affected by the small numbers in each group.

The application of propensity score matching methods identified a comparison group that were similar on available measured characteristics to the Brighter Futures children. However, the estimates of the program effect on early childhood outcomes in the scoping analysis did not differ substantively from a separate analysis that compared outcomes between Brighter Futures children and all untreated children in the general population.

Conclusion

The higher rates of injury-related emergency department visits and/or hospitalisations across all ages from birth to six years among children whose families were engaged and/or participated in the Brighter Futures program compared with children in the general population suggests there is scope to reduce injury in this vulnerable population. The addition of injury prevention measures to the suite of existing support services offered to Brighter Futures families may represent one opportunity to reduce injuries in vulnerable children known to child protection services in NSW.

The results from the propensity score matching scoping analysis highlighted some key challenges in retrospectively constructing a control group to estimate the effect of a program that was rolled out in the 'real world' in a non-random fashion. The difficulties in retrospectively constructing a valid comparison group, despite the linkage of multiple population datasets and the application of advanced epidemiological and statistical methods, emphasises the importance of designing program evaluation methods, including study design and data collection, before the implementation of new programs and services.

1 INTRODUCTION

1.1 Background

Injuries are a leading cause of child morbidity and mortality in Australia.[1,2] Around 200 children aged 0-14 years die from an injury,[2] and around 80,000 children aged 0-17 are hospitalised for an injury, each year.[1] Although child injury rates have decreased in Australia over the past decade, Aboriginal children and children growing up in more geographically remote areas and socioeconomically disadvantaged families, remain disproportionally affected.[3-8] There is also a growing body of evidence showing that children who live in families who are the subject of child abuse and/or neglect allegations have an increased risk of injury resulting in emergency department visits, hospitalisation and death, among other adverse outcomes, during childhood.[9-13]

Reporting of suspected child abuse and/or neglect is mandatory in New South Wales (NSW) and health care workers play an important role in the detection and reporting of suspected child abuse and/or neglect[14,15] Studies from the United States of America and Australia have shown that repeated emergency department visits and hospitalisation for injury might be an indication of child abuse and or/neglect.[9,11] Although injury might be a trigger for a child protection notification,[9,11] a study from the United states showed that children aged 0-5 with a prior allegation of child abuse or neglect remained at an increased risk of death from intentional and unintentional injury compared with children who had no child protection report during their first five years of life.[13,16] These findings suggest that injury prevention measures may be a valuable addition to existing services offered to families known to the child protection system.[13,16]

Despite the established association between child abuse and/or neglect allegations and emergency department visits and hospital admissions for injury,[9,11] to our knowledge, the burden of injury in children reported to child protection is not currently known in New South Wales (NSW). This information is important because the vast majority of child injuries are preventable.[17] At a population level, legislative measures, as well as product modification and safety campaigns, have contributed to a decrease in overall injury rates in children.[18-22] However, broad population level injury prevention strategies alone may not reach all population groups equally, if at all. In some cases, differences in access to, uptake of, or differential effectiveness of, interventions may even serve to widen inequalities in injury rates between population groups because one group benefits more than the other.[18,23] In contrast, injury prevention programs that are specifically targeted towards families most at risk of child injuries may reduce the overall burden of child injury in the general population, as well as inequalities between population groups.[22]

From a prevention perspective, it is notable that many of the family risk factors for child abuse and neglect are similar to those for child injury. For example, children from socioeconomically disadvantaged families are overrepresented among those who are the subject of child protection reports as well as injury.[4,9,24] In the Australian context, Aboriginal children are disproportionately impacted by child abuse and neglect, as well as injury, as evidenced by higher rates of child protection reports, and injury-related hospitalisations and deaths.[3,7,24,25] Moreover, families who are the subject of child protection reports often have one or more parental vulnerabilities, such as mental health problems, drug and alcohol use problems, domestic violence, and intergenerational abuse and neglect.[26,27] These parental vulnerabilities may also increase the risk of injury to children living in these families.[28,29]

Many early intervention and home visiting programs offer support to vulnerable families to support child health, child development and family functioning. To date, there is limited evidence regarding the effectiveness of home visiting programs in reducing child injuries.[18,30] A recent systematic review

of parenting interventions for the prevention of unintentional injuries in childhood found that multi-facetted interventions targeted at disadvantaged families have the potential to reduce child injury and increase uptake of home safety measures.[22] Although these programs were not necessarily designed as injury prevention programs, they have the potential to reduce child injuries because they also address some of the key risk factors that are common to injury, such as family functioning and parenting.[22] Moreover, home visiting programs present an opportunity to incorporate specific injury prevention measures in the context of an already established program, if there is an identified need. In NSW, the Brighter Futures program is a broad-based early intervention program that aims to support vulnerable families who have been reported to the child protection system.[31] To date, there is no information about the injury experience of children before and after their families participate in the program, to our knowledge.

1.2 The Brighter Futures program

In NSW, the Department of Family and Community Services (FACS) progressively rolled out the Brighter Futures program from 2003/4.[31,32] The program is an early childhood intervention program that was originally designed to deliver support services to vulnerable families of children to prevent them from entering the child protection system, or escalating in terms of intervention needs within the child protection system.[31] The initial eligibility criteria for Brighter Futures included families with a child less than nine years of age where the child is at high risk of entering the statutory child protection system and the parent/carer had at least one of the following vulnerabilities: domestic violence, drug or alcohol misuse, parental mental health issues, lack of parenting skills, significant learning difficulties, or intellectual disability.[31] In 2014, the program was realigned to prioritise families where children were identified at risk of significant harm (ROSH).[33] The description of the program throughout this report refers to the program until 31 December 2012, prior to its official realignment in 2014.

During the study period (2007-2012), the two most common ways that families entered into the program were via community referrals or child protection helpline reports that were considered below the statutory risk of significant harm threshold at the time of the report.[31] In NSW, reports of suspected risk of significant harm to children and young people are recorded by the Department of Family and Community Services.[25] After initial assessment, the risk of significant harm (ROSH) may be assessed by a child protection caseworker and their team.[25]A ROSH report that is substantiated indicates that there is sufficient reason to believe the child has been, is being, or is likely to be, abused, neglected or otherwise harmed. [14,25] If a child is considered not to be safe, action may be taken to have the child placed in out of home care (OOHC).[14,25] Families reported at suspected ROSH may also be offered support services and participation in home visiting and early intervention programs, one of which is the Brighter Futures program.[25,31]

The period when families are being assessed as suitable to participate in the program, and considering whether they are willing to participate, is referred to as “engagement”. After this initial phase, a family may go on to participate in the program. It is also possible for families to enter the program without a prior engagement period, which might be the case if a family is already known to an agency that delivers Brighter Futures. In NSW, the program is delivered by a range of non-government lead agencies. Participation in the program at the time of the study involved at least two of the following: placement of children within quality children’s services, parenting programs, home visiting, and brokerage funded support services.[31] The Brighter Futures program aims to enable children to live safely at home[31] and to this end, services are tailored to meet the particular needs of each family. Brighter Futures works with each family member living in the home, including

older siblings.

1.3 Study objectives

This study had three main objectives. The first objective was to characterise children and families who were engaged and/or participated in the Brighter Futures program. Children whose families who were engaged are of interest regardless of whether they participated in the program because they may have benefited from early intervention. The second objective was to quantify the burden of serious injury experienced by children whose families were engaged and/or participated in the program, and to compare injury outcomes with the same-age general population of children in NSW during the study period. The third objective was to examine the potential to apply quasi-experimental methods to linked cross-sectoral population data to assess the impact of the Brighter Futures program on early childhood outcomes, including serious child injury.

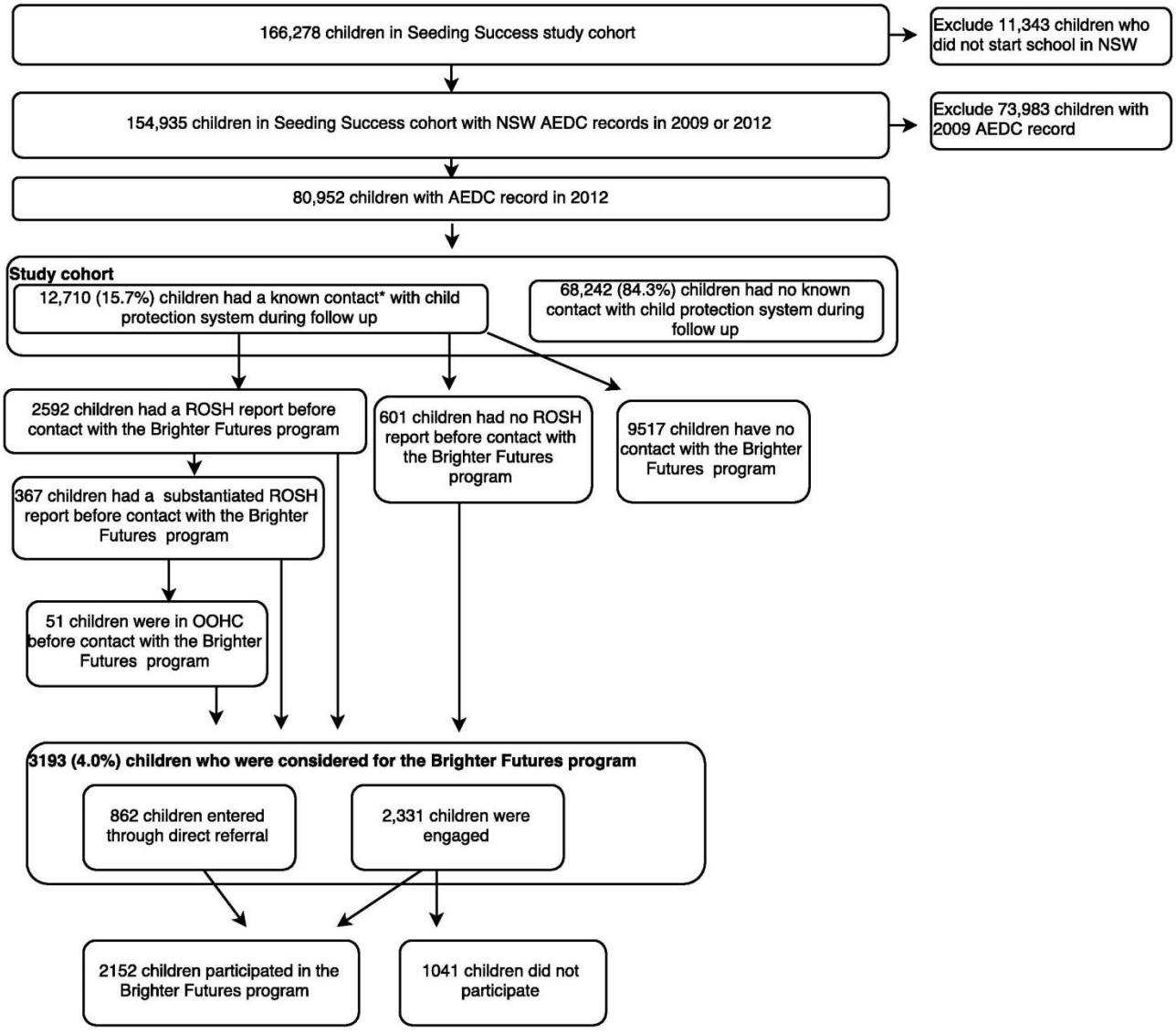
For this study, 'serious injury' was defined as emergency department and hospital admissions for injury. Although the original objective was to investigate emergency department and hospital admissions for unintentional injuries only, we expanded the definition to include all injuries because it is not currently possible to distinguish unintentional from intentional injuries recorded in the NSW Emergency Department Data Collection. The distinction between unintentional and intentional injuries can be useful because it suggests the most appropriate prevention or intervention approach.

2 METHODS

2.1 Study population

The study population described in this report was derived from the broader National Health and Medical Research Council (NHMRC)-funded Seeding Success study data resource, which has been described in detail elsewhere.[34] Briefly, the Seeding Success study data resource includes linked, cross-sectoral population data from health, education and community services for a population-based cohort of children who were born in NSW, and who started school and have an Australian Early Development Census (AEDC) record in 2009 or 2012 (n=166,278) (Figure 1). For this study, we restricted the study population to children who started school and had an AEDC record in NSW (N=154,624) because the Brighter Futures program is only available in NSW. Because Brighter Futures program data (described below) were only available from 2007, and we were unable to ascertain program participation in the early years of life for the 2009 school starters, we further restricted the study population to children who started school, and had an AEDC record, in NSW in 2012 (henceforth referred to as "2012 school starter cohort") (N=80,952) (Figure 1).

Figure 1: Identification of children whose families were considered for, and participated in, the Brighter Futures program from the Seeding Success study cohort.



*Any record of the following: risk of significant harm report, out of home care record or Brighter Futures program record.

2.2 Data sources and data linkage

The Seeding Success study cohort was derived via linkage of the AEDC data with the NSW Perinatal Data Collection and the NSW Register of Births, Deaths and Marriages birth registration data to follow children from birth to school age.[34] Linkage to other health, education and community service data sources provided information on child health and development trajectories during early childhood. Linkage of data sources for the Seeding Success study was conducted by the NSW Centre for Health Record and Data Linkage,[35] and de-identified datasets were supplied to the research team. A more detailed description of the data linkage process and original data sources are available in the Seeding Success study protocol.[34] For this study, we used all available linked data from the following data sources for children and parents in the study population from the time children were born until the end of their first year of school.

2.2.1 Australian Early Developmental Census

The Australian Early Developmental Census (AEDC) is a population measure of children's development in their first year of school, conducted every three years nationally.[36] It is an adapted version of the Canadian Early Development Instrument, developed in response to communities' increasing interest regarding how their children are developing. The AEDC checklist is completed by a teacher who has known the child for at least one month at the time of the census. Teachers provide information about the child's development on five domains, including: 1) physical health and well-being; 2) social competence; 3) emotional maturity; 4) language and cognitive skills; and 5) communication skills and general knowledge. At the time data were linked for the Seeding Success study, the AEDC data collection included records for approximately 181,500 children who started school in NSW in 2009 or 2012, which is estimated to be approximately 97.3% of the total school starter population in NSW in those years.[37,38]

2.2.2 NSW Perinatal Data Collection

The Perinatal Data Collection (PDC) includes records for all children born at 20 or more weeks gestation, or weighing 400 grams or more, in NSW public or private hospitals, as well as planned home births. It includes demographic variables, and information on maternal health, the pregnancy, labour, birth and perinatal outcomes.

2.2.3 NSW Registry of Births, Deaths and Marriages birth registrations

The Register of Births, Deaths and Marriages (RBDM) compiles birth registrations for NSW and includes date of birth, and Aboriginal status for mothers and other parents (mostly fathers).

2.2.4 NSW Admitted Patient Data Collection

The Admitted Patient Data Collection (APDC) includes records for all separations (discharges, transfers and deaths) from all NSW public and private sector hospitals and day procedure centres. These data are available from July 2000. APDC data are recorded in terms of episodes of care. An episode of care ends with the patient ending a period of stay in hospital (e.g. by discharge, transfer or death) or by becoming a different "type" of patient within the same period of stay. Patient demographics and diagnoses and procedures are recorded for each separation and coded according to the Australian modification of the International Statistical Classification of Diseases and Related Problems, 10th revision (ICD-10-AM).[39]

2.2.5 NSW Emergency Department Data Collection

The Emergency Department Data Collection (EDDC) contains records of emergency department visits in public hospitals in NSW from January 1 2005. Patient demographics and the primary diagnosis are recorded for each emergency department visit. However, in comparison to the APDC data, where diagnosis codes are entered by trained clinical information managers, diagnoses in the EDDC are collected by medical, nursing or clerical personnel at the point of care.[40] Diagnoses in the emergency EDDC data are coded according to the ICD-9-CM (Clinical Modification),[41] ICD-10-AM (Australian Modification)[39] International Statistical Classifications of Diseases and Related Health Problems and the Systematized Nomenclature of Medicine, Clinical Terms SMOMED -CT-AU terminology.[42] Around 60% of all emergency departments in NSW participated in the emergency EDDC in 2010 NSW,[35] but all larger emergency departments contributed to the emergency EDDC, resulting in high population coverage in major metropolitan areas, where the majority of the population lives, but less coverage in more geographically remote areas.[35]

2.2.6 Key Information Directory System

The Key Information Directory System (KIDS) is the NSW Department of Family and Community Services (FACS) electronic system for keeping records of its clients, which was introduced during 2003. It includes records of all client contacts with FACS, including information about whether a child: has been assessed as being at actual harm/risk of harm by a child protection caseworker; has had a legal decision made in relation to them (e.g. court orders); has been placed in OOHC (including type of care and number of placements); or has been referred to and participated in a Community Services intervention program (e.g. Brighter Futures, Intensive Families and other early intervention services). For the Seeding Success study cohort, the following records of contact with the child protection system in NSW were obtained: (1) child protection reports; (2) OOHC placements; and (3) Brighter Futures program data. In this report, reference to "known contact with the child protection system" refers to records from these three data sources that were linked to children in the study population. However, there may be other contacts with the child protection system for children in the cohort that are not available in the Seeding Success study data resource.

2.2.6.1 Child protection data

Of note, the statutory threshold for child protection reports increased in 2010 from "risk of harm" to "risk of significant harm".[43] Child protection data obtained for this study consisted of all reports for children in the study population that were classified at risk of harm prior to 2010 and those classified at risk of significant harm (ROSH) after 2010. These will be referred to as ROSH reports throughout the document. The child protection data records include the date of the ROSH report and whether the report was substantiated by a case worker. Child protection helpline calls that fell below the risk of harm or ROSH thresholds were not available in the study data.

2.2.6.2 Out of Home Care data

The Out of Home Care (OOHC) data for this study contains records of all children that had one or more placements in OOHC during the study period. The OOHC data contains information on the date and purpose of the OOHC placement.

2.2.6.3 Brighter Futures program data

The Brighter Futures program data contains information of families who were contacted (engaged) to participate in the program and families who participated in the program. The engagement period is defined as the initial period during which the agency assesses whether a family is suitable for the

Brighter Futures program and the family decides if they want to participate in the program. The engagement period typically lasts up to three months. If the family is deemed suitable, they may participate in the program, which typically lasts up to a maximum of two years.[27] The Brighter Futures program data contains information on the dates of engagement and program participation, duration of participation of families in the program, case closure reason and case outcome. There is no information regarding the type or frequency of services offered to participating families.

The Brighter Futures data are recorded at the family-level in the KIDS; however, data for the Seeding Success study were linked at the child-level. This means that engagement by, or participation in, the program may have been prompted by a child protection report concerning another member of the family, such as a younger or older sibling of a Seeding Success cohort child.

2.2.7 NSW Department of Education Public School Enrolment data

The NSW Department of Education collate data from the Application to Enrol in a NSW Government School form that is completed by the parents or caregivers of all children who enrol in a NSW Public School. Information recorded on these forms pertains to the student (e.g. age, sex) and the parents/ caregivers (e.g. sex, Aboriginality, occupation, highest level of schooling). For the Seeding Success study cohort, all linked Kindergarten Public School Enrolment records in 2009 and 2012 were obtained. School enrolment data were unavailable for children attending independent or Catholic schools, which equates to approximately 30% of the 2012 school starter cohort.

2.3 Study Outcome

The outcomes of interest in this study were emergency department visits and hospital admissions for injury. For the analysis these were grouped into injuries that were treated: 1) in the emergency department and/or hospital; 2) in the emergency department only; and 3) in the hospital. Hospitalised injuries included those that were treated in the hospital only, as well as transfers from the emergency department to a hospital for the same injury on the same day, or within one day. We distinguished between injuries treated in the emergency department only and those treated in the hospital in the analysis, because those requiring hospitalisation are typically more severe.

2.3.1 Identification of emergency department visits for injury in the EDDC

In NSW, the EDDC records the primary diagnosis at presentation in the emergency department; these are coded according to the ICD-9-CM (Clinical Modification)[41], ICD-10-AM (Australian Modification)[39] International Statistical Classifications of Diseases and Related Health Problems and the Systematised Nomenclature of Medicine, Clinical Terms, Australian (SMOMED-CT-AU) terminology.[42] In the EDDC, only the primary diagnosis at presentation is recorded. In 2% of injury-related emergency department admissions, we found that diagnoses were coded as the external cause of injury; for this reason, we included external cause codes in the definition of injuries for the analysis. In the case where ICD-9-CM and ICD-10-AM codes were used, we identified emergency department admissions for injuries using the following codes:

ICD-9-CM: 800-995, E800-E869, E880-929, E950-968, E980-989

ICD-10-AM: S00-T75, T79, V01-Y34, Y85-87 and Y89.

Injury events coded by the SNOMED-CT terminology were identified through linkage of the EDDC data with a SNOMED to ICD-10 international map supplied by the National E-Health Transition Authority (NEHTA) and a SNOMED to ICD10-AM map for injury codes SOO-S75 and S79 supplied by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). Using these maps,

injuries were identified through mapping of SNOMED codes to ICD-10 injury codes to. The completeness of identification of SNOMED injury codes were assessed by reviewing codes that were not identified as injuries using theses maps, and SNOMED injury codes not identified by the maps were added to the injury codes.

2.3.2 Identification of hospital admissions for injury in the APDC

In the APDC, hospital admissions for injury were identified using the following ICD-10-AM codes recorded in the primary diagnosis field: SOO-T75 or T79.

2.3.3 Identification of emergency department to hospital transfers and same day admissions

We defined emergency department to hospital transfers for individual children as emergency department and hospital admissions that: (1) had the same primary diagnosis code, and (2) had admission dates on the same day, or within one day, of each other. When an individual child had one or more emergency department or hospital admissions with matching admission dates and primary diagnosis codes, the additional records were excluded from the analysis because they were likely to be duplicates or repeat admissions for the same injury.

2.4 Exposure

The main exposure under investigation was Brighter Futures program engagement and/or participation. For the analysis of injuries before and after Brighter Futures participation, all children whose families participated in the program were defined as exposed, regardless of the duration of program participation.

2.5 Comparison groups

For the descriptive analysis, we compared injury outcomes in children whose families were engaged and/or participated in the Brighter Futures program with children in the study population who had no known contact (ROSH report, OOHC or Brighter Futures) with the child protection system between birth and the end of their first year of school.

For the propensity score matching scoping analysis,[44] we attempted to identify a comparison group of children who had similar characteristics to children of families who participated in the Brighter Futures program, but who did not participate in the program. Characteristics of the child, the family and the area where they lived that were available in the source data were used in the propensity score matching analysis (see Appendix 6.2).

2.6 Analysis variables

For this study, child and family characteristics were derived from the birth (PDC, APDC, RBDM) and school age (AEDC) source data that were linked for children in the study population. Characteristics of the child included: Aboriginal status, sex, age, private health insurance status, history of child protection reports and pre-school attendance. Due to known under-reporting of Aboriginality in administrative datasets,[45] multiple sources were used to identify Aboriginal children including the AEDC, PDC, RBDM and APDC data. Characteristics of the mother included: Age, marital status, country of birth and smoking during pregnancy. Area-characteristics assigned to the statistical local area recorded on the child's birth record were: geographical remoteness and socioeconomic disadvantage of the area of residence. Remoteness of residence was classified using the Accessibility/ Remoteness Index of Australia (ARIA+),[46] grouped into four categories: major city,

inner regional, outer regional and remote/very remote areas. Area-level socioeconomic disadvantage was based on the Australian Bureau of Statistics' Socio-Economic Index for Areas (SEIFA) Index of Relative Social Advantage and Disadvantage,[47] divided into population quintile groups (Table 1).

Table 1: Child, mother and area characteristics in the analysis

	Variables
Child	Sex, age, private health insurance status, Aboriginal status, child protection report, pre-school attendance
Mother / parents	Mother's age, mother's country of birth, maternal age at childbirth, marital status at childbirth, maternal smoking during pregnancy
Area	Geographic remoteness (ARIA+) Area-level socioeconomic disadvantage (SEIFA)

2.7 Statistical analysis

The data structure for the analysis was based on the counting process frame,[48,49] where the follow up time is divided into injury periods.

2.7.1 Analysis of injury events

In the analysis of the number of injuries during the study period, person-years at risk were calculated from birth to the end of follow up (i.e. December 31, 2012, which equates to the end of the first year of school). In the analysis of injuries in children of families who participated in the Brighter Futures program, person-years at risk were calculated from birth to Brighter Futures participation start date (before) and from program participation start date to the end of follow up (after). Rates of injuries treated in the emergency department and/or hospital were calculated as the number of emergency department and hospital admissions per person years at risk. Confidence intervals (CIs) were calculated assuming a Poisson distribution for emergency department visits and hospital admissions due to injury.

Differences in emergency department visits and hospital admissions due to injury between children of families who were engaged and/or participated in the Brighter Futures program and children who had no known contact with the child protection system during the study period were calculated as the rate difference (absolute inequality) and rate ratios (relative inequality).[50] The absolute inequality was calculated by subtracting the injury rate in children who had no known contact with the child protection system from that in children of families who were engaged and/or participated in the program. The relative inequality was calculated by dividing the injury rate for children of families who were engaged and/or participated in the program by the injury rate for children who had no known contact with the child protection system. Statistical analyses were carried out using Stata 12[51] and SAS 9.3.[52]

2.7.2 Propensity score matching scoping analysis

A scoping analysis was performed to assess the feasibility of applying propensity score matching to estimate the effect of Brighter Futures participation on subsequent early childhood outcomes. Propensity score matching is a quasi-experimental methodology used to estimate treatment effects in the absence of randomised treatment assignment; in practice, this method involves identification of statistically equivalent treated and control groups using available data.[44] The propensity scores

refers to the estimated probability of receiving a treatment, in this case participation in Brighter Futures; conditioning on this score aims to correct for observed and unobserved differences between children and families who did and did not participate in the program, which can otherwise bias estimates of the treatment effect. Appendix 6.2 provides further background on the propensity score matching approach, as well as describing some practical challenges arising in its application to investigate the impact of the program. Propensity scores were estimated using the same covariates used in the main analysis (Table 1) and two applications of these scores—1:2 matching and inverse probability of treatment weights—were used to estimate the effect of Brighter Futures participation on early childhood development, obtained from the AEDC. The results of the scoping analysis indicated that, with the currently available data, applying propensity score matching offered little additional benefit over more immediate comparisons to the general population of children. For this reason, the propensity score matching analysis was not applied to the analysis of injuries presented in the main body of this report.

2.8 Ethical and data custodian approvals

The Seeding Success study, including this sub-study, received ethical approval from the NSW Population and Health Services Research Ethics Committee (AU RED Reference: HREC/14/CIPHS/23, Cancer Institute NSW reference: 2014/04/523), the NSW Aboriginal Health and Medical Research Council Ethics Committee (1031/14), the Australian Institute of Health and Welfare Ethics Committee (EO2015/2/141) and the Australian National University Human Research Ethics Committee (2014/384).

2.9 Study governance

This study is a sub-study of the broader NHMRC-funded Seeding Success study. The Seeding Success Investigator team oversees all scientific activities of the Seeding Success study, and includes academics from institutions nationally and internationally with expertise in child health and development, Aboriginal maternal and child health, epidemiology, statistics, health services research, and educational psychology, as well as policy representatives from health and community services in NSW. Since the study's inception, the Seeding Success Investigator team has met every 3-6 months. As part of the Seeding Success study community engagement strategy, a Reference Group consisting of Aboriginal community organisations, service providers and their representatives was established in 2015 to provide the Investigators with guidance on the study aims, priorities and interpretation of the findings, to advise on community engagement, and to connect with relevant groups and organisations to facilitate translation of findings into policy and practice. Progress with this sub-study was discussed with the Reference Group in October 2016.

2.10 Policy engagement

This study was conducted in partnership with the Department of Family and Community Services (FACS) Analysis and Research directorate, which facilitated access to data from the Key Information Directory System (KIDS), and ongoing discussions with policy and information management representatives at FACS regarding appropriate use of the KIDS data, development of the analysis plan for this study, and interpretation and dissemination of findings. Additionally, some authors of this report regularly participated in meetings of the NSW Health Paediatric Injury Reference Group in 2015-2016. The Paediatric Injury Reference Group consists of Paediatricians, researchers, policy makers, Kidsafe, and other organisations identified as key stakeholders in child injury prevention in NSW. Progress with this study was reported and discussed with members of the Paediatric Injury Reference Group throughout 2015-16.

3 RESULTS

Of the 80,952 children in the 2012 school starter cohort, the majority of children (67.5%, n=54,611) were aged six years and 31.8% (n=25,744) were aged five years at the end of the study period (December 31 2012, which is the end of the children's first year of school). Only a small proportion of children were four or seven years old (0.7%, n=597). The results in this section of the report pertain to children in the 2012 school starter cohort.

3.1 Known contacts with the child protection system

Of the 80,952 children in the 2012 school starter cohort, 68,242 (84.3%) children had no known contact with the child protection system during the study period, whereas 12,710 (15.7%) children had at least one ROSH report, Brighter Futures record, or OOHC placement between birth and the end of their first year of school (Figure 1, Table 2). Of the 2012 school starter cohort, 12,324 (15.2%) children had a risk of significant harm report, 3,314 (4.1%) a substantiated risk of significant harm report, 1,378 (1.7%) were placed in OOHC and 3,193 (3.9%) had a Brighter Futures record during the study period (Figure 1, Figure 2, and Table 2). Of the 3,193 children of families who were contacted by Brighter Futures, 2,592 (81.2%) had a prior ROSH report, 367 (11.5%) had prior substantiated ROSH reports and 51 (1.6%) had a prior OOHC placement. Of the 3,193 families who were engaged and/or participated in the program, 1,041 families (32.6%) did not participate in the program (engagement only). The remaining 2,152 families (67.4%) participated in the program.

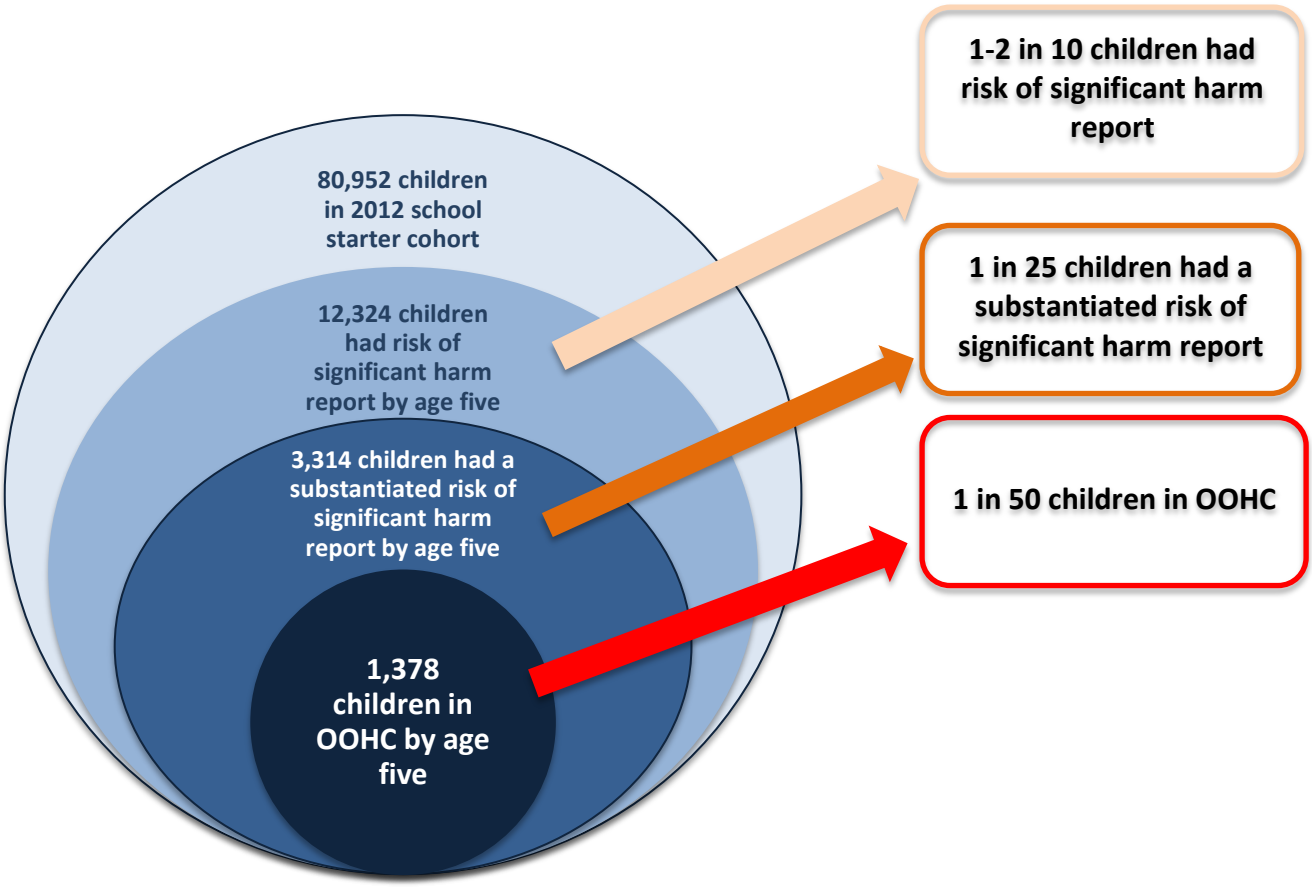
Table 2: Child protection and Brighter Futures program histories of the 80,952 children in the 2012 school starter cohort, by Brighter Futures program participation and child protection history from birth to the end of the child's first year of school.

	Number of children	**Percentage[a]**
2012 school starter cohort	80,952	100
No known contact with child protection system	68,242	84.3
Any known contact with child protection system	12,710	15.7
ROSH report	12,324	15.2
Substantiated ROSH report	3,314	4.1
OOHC placement	1,378	1.7
Brighter Futures engagement and/or participation	3,193	3.9
	Number of children	**Percentage[b]**
Brighter Futures engagement and/or participation	3,193	100
Brighter Futures participation	2,152	67.4
Brighter Futures engagement only	1,041	32.6
ROSH report before Brighter Futures engagement and/or participation	2,592	81.2
Substantiated ROSH report before Brighter Futures engagement and/or participation	367	11.5
OOHC placement before Brighter Futures engagement and/or participation	51	1.6
No ROSH report before Brighter Futures engagement and/or participation	601	18.8

ROSH, risk of significant harm; OOHC, out of home care.

a. The denominator for the calculation of percentages in the first section of the table is the 80,952 children in the 2012 school starter cohort; b. the denominator for the calculation of percentages in the second section of the table is the 3,193 children who were engaged and/or participated in the Brighter Futures program.

Figure 2: Number of children in the 2012 school starter cohort with known contact with NSW child protection system between birth and the end of their first year of school.



3.2 Child's age at family's Brighter Futures engagement and/or participation

The mean age of children when their families had their first contact with the Brighter Futures program was 2.4 years (95% CI 2.3-2.4). Almost two thirds of families were first engaged and/or participated in the program when the child was between one and three years old (60.5%, n=1933) (Figure 3, Table 3).

Figure 3: Child's age at their family's first Brighter Futures engagement and/or participation.

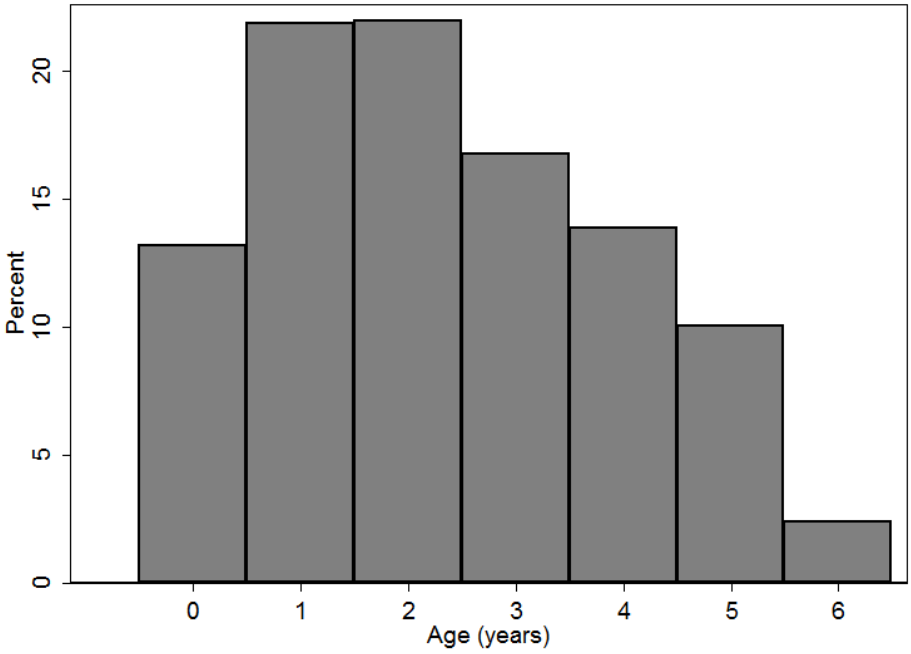


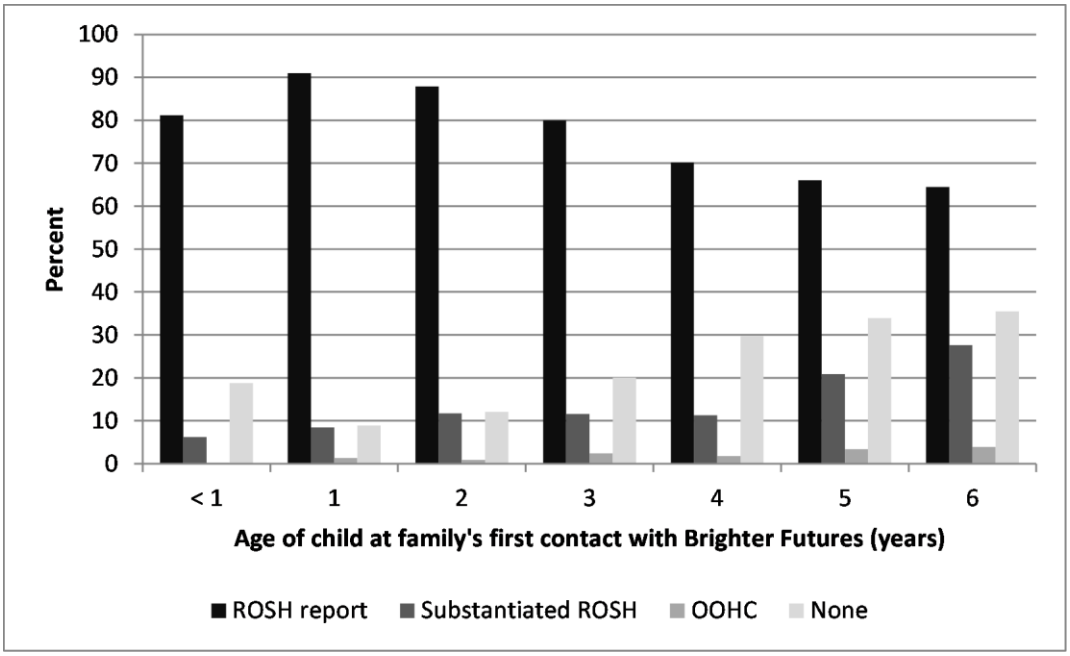
Table 3: Child's age at their family's first Brighter Futures engagement and/or participation.

Age (years)	Number	Percent
<1	420	13.15
1	698	21.86
2	701	21.95
3	534	16.72
4	443	13.87
5	321	10.05
6	76	2.38
Total	3,193	100

3.3 Child protection histories prior to Brighter Futures engagement and/or participation

Of the 3,193 children whose families were contacted by the Brighter Futures program before the end of their first year of school, 81.2% (n=2,592) had prior histories of ROSH reports and/or OOHC placements. The proportion of children with a known interaction with community services prior to their family's engagement and/or participation with Brighter Futures varied by the child's age when their family had their first contact with the program. For each year of age between birth and six years, 65-91% of children had at least one ROSH report, 6-28% had at least one substantiated ROSH report and 0.2-4% had at least one OOHC placement before the family was engaged and/or participated in the program (Figure 4).

Figure 4: Percent of children with risk of significant harm (ROSH) reports, substantiated ROSH reports, and out-of-home care placement records, before Brighter Futures program engagement and/or participation, stratified by the child's age at their family's first contact with the program.*[#]



ROSH, risk of significant harm; OOHC, out of home care.

*The threshold for mandated child protection reports increased in January 2010 from 'risk of harm' to 'risk of significant harm'. Twenty five percent of children whose families were engaged and/or participated in the Brighter Futures program in the study population were aged two years and 71% were aged three years on the first of January 2010.

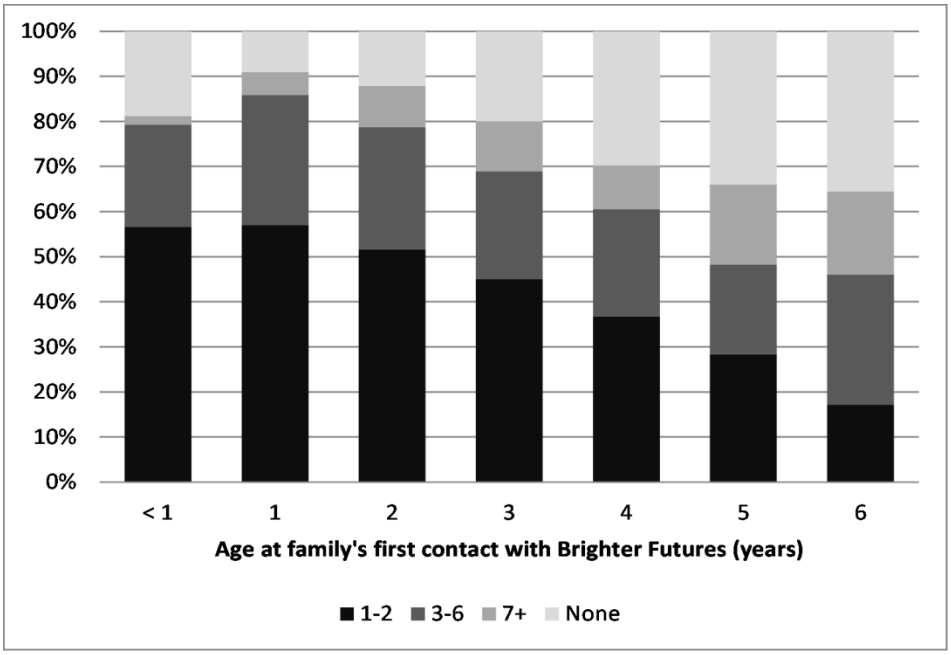
[#]The sum of ROSH and substantiated ROSH reports by age category may exceed 100% if children had both types of reports during the same year of life.

The percent of children with at least one ROSH report before their family was engaged and/or participated in the Brighter Futures program was higher in the children whose families had first contact with the program at younger ages (i.e. 81%, 91%, 88%and 80% in children who were less than one year old (n=341), 1 year old (n=635), 2 years old (n= 613) and 3 years old (n=427), respectively), compared with older ages (i.e. 70%, 66% and 65% in children who were four years (n=311), five years (n=212) and six years (n=49) old, respectively).

The lower percent of ROSH reports in the children whose families had first contact with Brighter Futures when they were 3 years or older may in part reflect the change in the statutory threshold from risk of harm to risk of significant harm in 2010.[43] At this time the majority of children in this cohort were 2-3 years of age. It may also reflect that families with young children are most likely to be referred to Brighter Futures and ROSH reports in older children in our study cohort may have

been prompted by a child protection report concerning a younger sibling. In contrast, the percent of children with substantiated ROSH reports and OOHC placements before Brighter Futures program engagement and/or participation was higher in children who were older when their family first had contact with the program. Of children aged less than one year when their family first had contact with Brighter Futures, 6.2% (n=26) had a substantiated ROSH report and 0.2% (n<5) an OOHC placement (Figure 4). In comparison, 20.9% (n=67) and 3.4% (n=11) of children who were six years old at first Brighter Futures contact had a substantiated ROSH report or an OOHC placement before program engagement and/or participation, respectively (Figure 4).

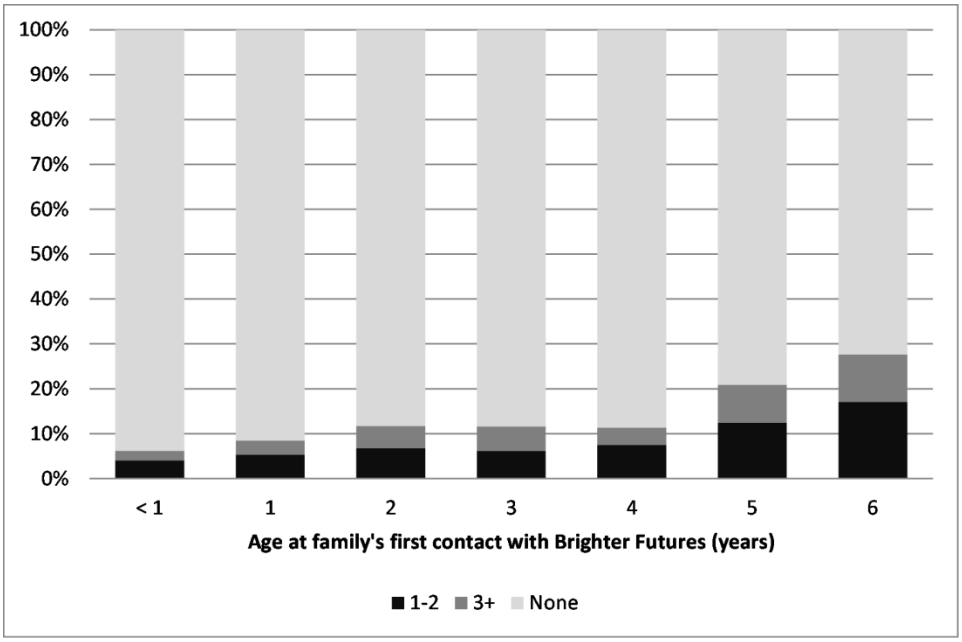
Figure 5: Percentage of children with risk of significant harm reports (ROSH), by number of ROSH reports, before family's Brighter Futures program engagement and/or participation, stratified by the child's age at their family's first contact with the program.*



*The threshold for mandated child protection reports increased in January 2010 from 'risk of harm' to 'risk of significant harm'. Twenty five percent of children whose families were engaged and/or participated in the Brighter Futures program in the study population were aged two years and 71% were aged three years on the first of January 2010.

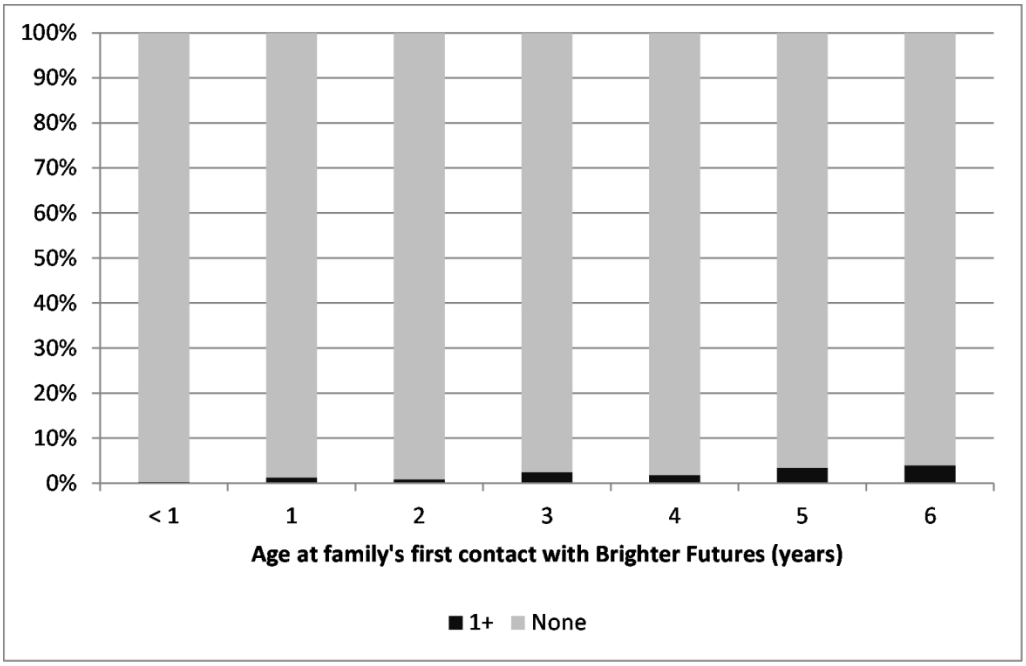
The accumulated number of previous ROSH reports for children whose families were engaged and/or participated in Brighter Futures varied by the age of the child at their family's first contact with the program. The percent of children who had 1-2 ROSH reports before Brighter Futures engagement and/or participation was higher in children whose family had first contact with the program at younger ages compared with older ages; for example, 58% (n=238) of children aged less than one year compared with 17.1% (n=13) of children aged six years had 1-2 ROSH reports prior to the family's contact with the program (Figure 5). In contrast, the percentage of children who had 3-6, or more than seven, ROSH reports before their family's engagement and/or participation in the Brighter Futures program was higher in children who were older at first contact. Of children whose families were engaged and/or participated in the program when they were less than one year old, 23% (n=95) had 3-6 ROSH reports, and 1.9% (n=79) had more than seven prior ROSH reports. In comparison, 29% (n=22) and 18% (n=27) of children who were six years old when their families were engaged and/or participated in the program, had 3-6 ROSH reports or more than seven ROSH reports, respectively.

Figure 6: Percentage of children with substantiated ROSH reports before their families were engaged and/or participated in the Brighter Futures program, stratified by child's age at family's first contact with the program.



Of the 2,592 children with any ROSH report prior to Brighter Futures engagement and/or participation, 367 (14%) children had a substantiated ROSH report at the time their family had first contact with the program. The number of substantiated ROSH reports per child before Brighter Futures engagement and/or participation ranged from 0-21. Notably, the percentage of children with a substantiated ROSH report before programs engagement and/or participation was higher in children who were older at the family's first contact with the Brighter Futures program. Of children aged less than one year when their families first engaged and/or participated in the program, 4.0% (n=17) had a prior substantiated ROSH report (Figure 6). In comparison, 17.1% (n=13) of children aged six when their families first engaged and/or participated in the program had a prior substantiated ROSH report.

Figure 7: Percent of children with out-of-home care placement records before their families were engaged and/or participated in the Brighter Futures program stratified by child's age at family's first contact with the program.



Of the 2,592 children of families who were engaged and/or participated in the Brighter Futures program, 51 (2%) children were placed in OOHC prior to their family's engagement and/or participation in the program (Figure 7). The number of OOHC placement records before their families were engaged and/or participated in the program ranged from 0-16. The percentage of children who had previously been placed in OOHC ranged from 0.2% in children who were less than one year old, to 4% in those who were six years old, at the family's first contact with Brighter Futures.

3.4 Characteristics of children whose families were engaged and/or participated in the Brighter Futures program compared with children who had no known contact with the child protection system

The characteristics of children whose families were engaged and/or participated in the Brighter Futures program differed significantly ($p<0.001$) from children who had no known contact with the child protection system between birth and the end of their first year of school, for all available characteristics except gender (Table 4).

Compared to children who had no known contact with the child protection system during early childhood, children of families who were engaged and/or participated in the Brighter Futures program were more likely to: be Aboriginal (24.5% versus 5.7%); have low birthweight (9.6% versus 4.8%); be born prematurely (9.9% versus 5.9%); have special needs (13.3% versus 4.1%); and less likely to have attended day care or preschool (72.8% versus 84.5%).

The mothers of Brighter Futures children were younger (16.1% aged less than 20 years) and fewer were married or living in a de-facto relationship (50.4%) compared with mothers of children who had no known contact with the child protection system during early childhood (1.9% aged less than 20 years and 86.8% married or living in a de-facto relationship). A higher percentage of Brighter Futures

mothers smoked during pregnancy (41.6%, n=1,330) compared to mothers of children who had no known contact with the child protection system (8.5%, n=5,788). A lower percentage of families who were engaged and/or participated in the Brighter Futures program had private health insurance/patient status at the child's birth (8.6%, n=276) compared with families of children with no known contact with the child protection system during early childhood (41.9%, n=28,584).

A higher percentage of children whose families were engaged and/or participated in the Brighter Futures program lived in the most disadvantaged (17%, n=543) and remote areas (2.8%, n=91) compared with children who had no known contact with the child protection system (8.1%, n=5,546 and 0.7%, n=480, respectively) during early childhood.

Table 4: Characteristics of children whose families were engaged and/or participated in the Brighter Futures program compared with children who had no known contact with the child protection system between birth and the end of their first year of school.

			No known contact with child protection (N=68,242)	Brighter Futures (N=3,196)	Total	
			n (%)	n (%)	n (%)	
Child characteristics	**Sex**	Boys	34905 (51.1%)	1663 (52%)	36568 (51.2%)	p=0.3
		Girls	33337 (48.9%)	1533 (48%)	34870 (48.8%)	
	Aboriginality*	Non-Aboriginal	65496 (96%)	2413 (75.5%)	67909 (95.1%)	p<0.001
		Aboriginal	2746 (4%)	783 (24.5%)	3529 (4.9%)	
	Low birth weight (<2500g)	No	64206 (94.1%)	2837 (88.8%)	67043 (93.8%)	p<0.001
		Yes	3269 (4.8%)	307 (9.6%)	3576 (5%)	
		Missing	767 (1.1%)	52 (1.6%)	819 (1.1%)	
	Preterm birth (gestational age <37 weeks)	No	63490 (93%)	2832 (88.6%)	66322 (92.8%)	p<0.001
		Yes	4010 (5.9%)	315 (9.9%)	4325 (6.1%)	
		Missing	742 (1.1%)	49 (1.5%)	791 (1.1%)	
	Medically diagnosed special needs	No special needs	65452 (95.9%)	2770 (86.7%)	68222 (95.5%)	p<0.001
		Special needs	2790 (4.1%)	426 (13.3%)	3216 (4.5%)	
	Child attended day care or pre-school program in year before school	No	5377 (7.9%)	479 (15%)	5856 (8.2%)	p<0.001
		Yes	57645 (84.5%)	2326 (72.8%)	59971 (83.9%)	
		Missing	5220 (7.6%)	391 (12.2%)	5611 (7.9%)	
Mother's characteristics	**Maternal age at childbirth (years)**	<20	1322 (1.9%)	516 (16.1%)	1838 (2.6%)	p<0.001
		20-24	8144 (11.9%)	926 (29%)	9070 (12.7%)	
		25-29	18441 (27%)	760 (23.8%)	19201 (26.9%)	
		30-34	24228 (35.5%)	598 (18.7%)	24826 (34.8%)	
		35+	16105 (23.6%)	396 (12.4%)	16501 (23.1%)	
	Mother born in Australia?	No	19494 (28.6%)	515 (16.1%)	20009 (28%)	p<0.001
		Yes	48366 (70.9%)	2665 (83.4%)	51031 (71.4%)	
		Missing	382 (0.6%)	16 (0.5%)	398 (0.6%)	
	Married or in de facto partnership at child's birth	No	7242 (10.6%)	1349 (42.2%)	8591 (12%)	p<0.001
		Yes	59215 (86.8%)	1611 (50.4%)	60826 (85.1%)	
		Missing	1785 (2.6%)	236 (7.4%)	2021 (2.8%)	
	Smoking during pregnancy?	No	60819 (89.1%)	1784 (55.8%)	62603 (87.6%)	p<0.001
		Yes	5788 (8.5%)	1330 (41.6%)	7118 (10%)	
		Missing	1635 (2.4%)	82 (2.6%)	1717 (2.4%)	
	Number of previous pregnancies	0	28303 (41.5%)	1201 (37.6%)	29504 (41.3%)	p<0.001
		1	23627 (34.6%)	930 (29.1%)	24557 (34.4%)	
		2	10168 (14.9%)	516 (16.1%)	10684 (15%)	
		3	3259 (4.8%)	243 (7.6%)	3502 (4.9%)	
		4	1026 (1.5%)	126 (3.9%)	1152 (1.6%)	
		5+	697 (1%)	116 (3.6%)	813 (1.1%)	
		Missing	1162 (1.7%)	64 (2%)	1226 (1.7%)	
	Private patient or private health insurance at child's birth	No	38906 (57%)	2870 (89.8%)	41776 (58.5%)	p<0.001
		Yes	28584 (41.9%)	276 (8.6%)	28860 (40.4%)	
		Missing	752 (1.1%)	50 (1.6%)	802 (1.1%)	

*Due to known under-reporting of Aboriginality in administrative datasets, information from multiple sources was combined to help to identify Aboriginal children; children were classified as Aboriginal if they or their parent were recorded as Aboriginal on one or more of the birth or school age records in the AEDC (child's status), PDC (mother's status), RBDM (mother's and other parent's status) or APDC (mother's and child's status).

Table 4 continued: Characteristics of children whose families were engaged and/or participated in the Brighter Futures program compared with children who had no known contact with the child protection system between birth and the end of their first year of school.

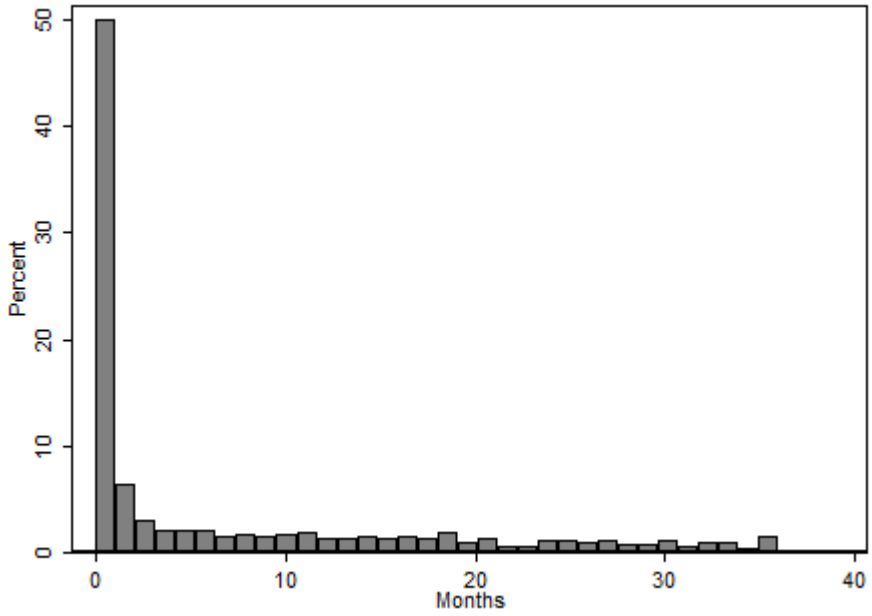
			No known contact with child protection	Brighter Futures	Total	
			Number (%)	Number (%)	Number (%)	
Area characteristics	**Area-level socioeconomic disadvantage quintiles**	1 (Most disadvantaged)	5546 (8.1%)	543 (17%)	6089 (8.5%)	p<0.001
		2	7467 (10.9%)	565 (17.7%)	8032 (11.2%)	
		3	22971 (33.7%)	1364 (42.7%)	24335 (34.1%)	
		4	14418 (21.1%)	459 (14.4%)	14877 (20.8%)	
		5 (Least disadvantaged)	17838 (26.1%)	265 (8.3%)	18103 (25.3%)	
	Accessibility/ Remoteness Index of Australia	Major City	43976 (64.4%)	1456 (45.6%)	45432 (63.6%)	p<0.001
		Inner Regional	17977 (26.3%)	1140 (35.7%)	19117 (26.8%)	
		Outer Regional	5807 (8.5%)	509 (15.9%)	6316 (8.8%)	
		Remote/Very Remote	480 (0.7%)	91 (2.8%)	571 (0.8%)	

*Due to known under-reporting of Aboriginality in administrative datasets, information from multiple sources was combined to help to identify Aboriginal children; children were classified as Aboriginal if they or their parent were recorded as Aboriginal on one or more of the birth or school age records in the AEDC (child's status), PDC (mother's status), RBDM (mother's and other parent's status) or APDC (mother's and child's status).

3.5 Timing and duration of Brighter Futures participation

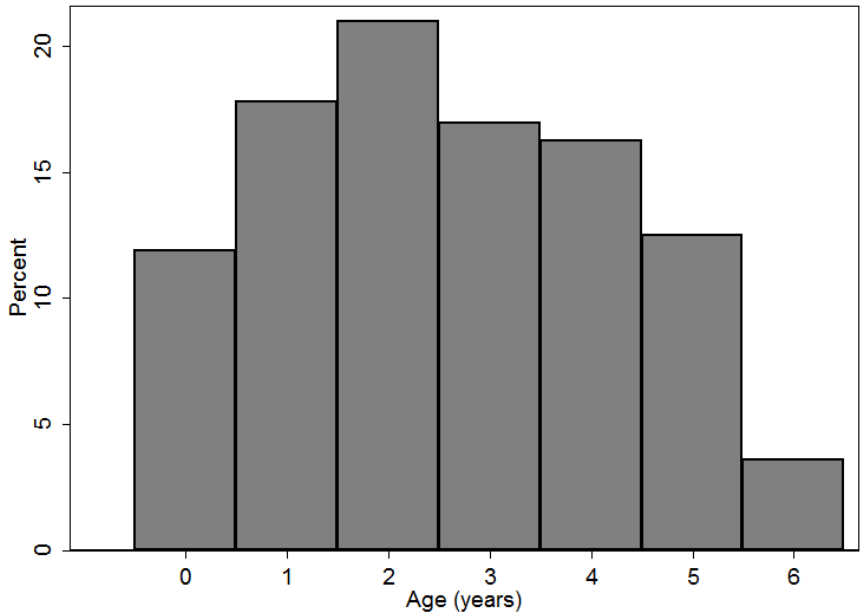
Of the 3,193 children whose families were contacted by Brighter Futures, 2,152 (67%) children and their families participated in the program. Of these, 862 children and their families were directly referred to the program and did not have an engagement period prior to program participation. Almost half (n=1,583) of children and their families participated in the program within three months of the first known contact with the child protection system (Figure 8). The median time between first known contact with the child protection system , and the child's family participating in the program, was 135 days (IQR 19-730 days), which equates to four and a half months.

Figure 8: Time in months between first known contact with child protection system* and Brighter Futures program participation.#



*The first of all the linked records from the KIDS data that are available in the Seeding Success study data resource, including risk of significant harm reports, Brighter Futures program records, and out-of-home care placement records. There may have been other contacts with the child protection system for study children and their families prior to program participation that were not included in this resource.# Truncated at 36 months.

Figure 9: Child's age when the family first participated in the Brighter Futures program.



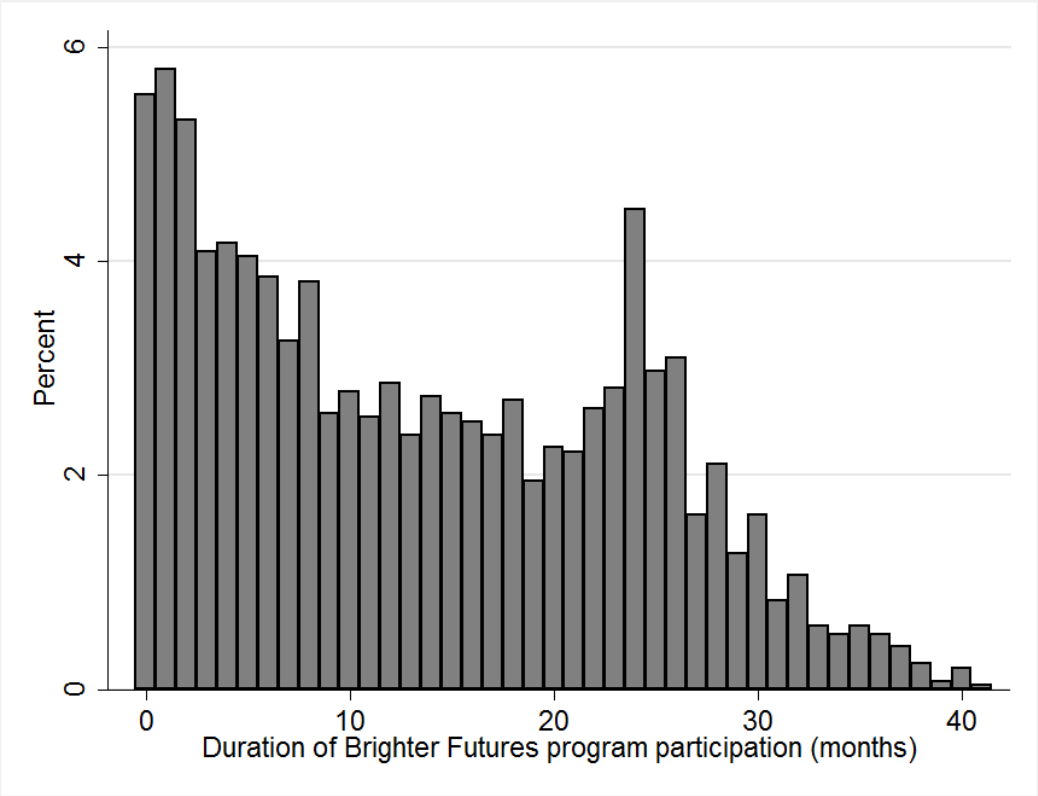
The mean age of study children when their families first participated in the program was 2.6 years (95% CI 2.5-2.7); more than half of the children were aged 1-3 years when the family first participated in the Brighter Futures program (55.7%, n=1200) (Figure 9, Table 5).

Table 5: Child's age when the family first participated in the Brighter Futures program.

Age (years)	Number	Percent
0	256	11.9
1	383	17.8
2	452	21.0
3	365	17.0
4	350	16.3
5	269	12.5
6	77	3.6
Total	2,152	100

The duration of Brighter Futures program participation varied between 1 and 71 months and the median duration was 1 year and 1 month, which is equivalent to 394 days (interquartile range (IQR), 155-710 days). Approximately 20% (n=389) of children and their families participated in the program for four month or less (Figure 10).

Figure 10: Duration of Brighter Futures participation.*

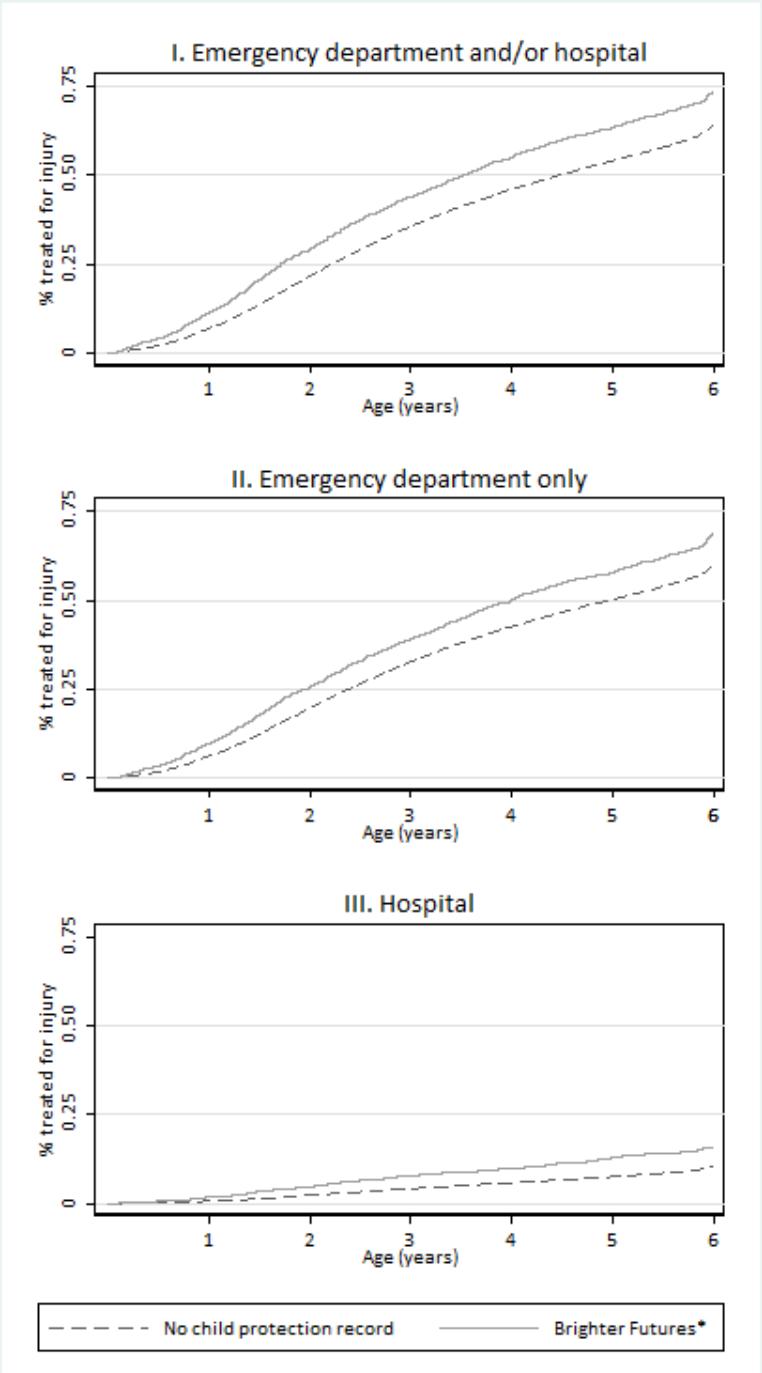


*Truncated at 99% of duration of Brighter Futures program participation (i.e. 41 months)

3.6 Emergency department visits and/or hospital admissions for injury in children whose families were engaged and/or participated in the Brighter Futures program.

Between birth and the end of their first year of school, 47% (n=1,501) of children whose families were engaged and/or participated in the Brighter Futures program had a total of 2,727 injury-related emergency department visits and/or hospital admissions (Figure 11). This translates to an average of 1.81 (95% CI 1.75-1.88) injury-related emergency department visits and/or hospital admissions per child. The majority of these injuries were treated in the emergency department only (85.5%, n=2,333), and 14.5% (n=394) were treated in the hospital (Appendix Table 6, Table 7, Table 8). In comparison, 34.9% (n=23,806) of children who had no known contact with the child protection system during the study period had a total of 36,100 injury-related emergency department visits and/or hospital admissions during the same period (Figure 11). This translates to an average of 1.51 (95% CI 1.50-1.53) injury-related emergency department visits and/or hospital admissions per child (Figure 11). The majority of these injuries were treated in the emergency department only (87.9%, n=31,720), and 12.1% (n=4,380) were treated in the hospital (Appendix Table 6, Table 7, Table 8).

Figure 11: Cumulative incidence of injury-related emergency department visits and/or hospital admissions among children whose families were engaged and/or participated in the Brighter Futures program compared with children who had no known contact with the child protection system before the end of their first year at school. I Emergency department visits and/or hospital admission; II Emergency department visit only; III Hospital admissions.



* Brighter Futures program engagement and/or participation.

3.6.1 Rates of emergency department visits and/or hospital admissions for injury by age

3.6.1.1 Emergency department visits and/or hospital admissions

Although the rates of injury related emergency department visits and/or hospital admissions were higher among children whose families were engaged and/or participated in the Brighter Futures program compared with children with no known contact with the child protection system during the study period, the pattern of injury related emergency department visits and/or hospital admissions were similar across the age range in both groups of children (Figure 12, Appendix 6.1 Table 6).

Rates of injury-related emergency department visits and/or hospital admissions ranged from 82 per 1,000 person years (95% CI 72-93) to 169 per 1,000 person years (95% CI 155-184) across 1-year age groups between birth and six years of age in children whose families were engaged and/or participated in the Brighter Futures program. In children who had no contact with the child protection system during the study period, rates of injury-related emergency department visits and/or hospital admissions ranged from 40 per 1,000 person years (95% CI 39-42) to 112 per 1,000 person years (95% CI 110-114). Rates of injury-related emergency department visits and/or hospital admissions peaked in children aged two years in both groups of children; rates were 169 injuries per 1,000 person years (95% CI 155-184) in children whose families were engaged and/or participated in the program and 112 injuries per 1,000 person years (95% CI 110-114) in children who had no known contact with the child protection system during the study period (Figure 12, Appendix 6.1 Table 6).

For each year of age between birth and six years, the rate difference for injury-related emergency department visits and/or hospital admissions between children whose families were engaged and/or participated in the Brighter Futures program and children with no known contact with the child protection system ranged from 42 per 1,000 person years (95% CI 30-56) to 64 per 1,000 person years (95% CI 49-82). The rate ratio of injury-related emergency department visits and/or hospital admissions between children whose families were engaged and/or participated in the program and children with no known contact with the child protection system ranged from 1.5 to 2.0 across the age range (Appendix 6.1 Table 6).

3.6.1.2 Emergency department visits

The patterns of rates of injury treated in the emergency department only were similar to those treated in the emergency department and/or hospital. Rates of injury-related emergency department visits ranged from 69 per 1,000 person years (95% CI 60-79) to 143 per 1,000 person years (95% CI 130-157) across 1-year age groups between birth and six years of age in children whose families were engaged and/or participated in the Brighter Futures program. In children who had no contact with the child protection system during the study period, rates of injury-related emergency department visits ranged from 36 per 1,000 person years (95% CI 35-37) to 100 per 1,000 person years (95% CI 97-102). Rates of injury-related emergency department visits peaked in children aged two years in both groups of children. (Figure 12, Appendix 6.1 Table 7).

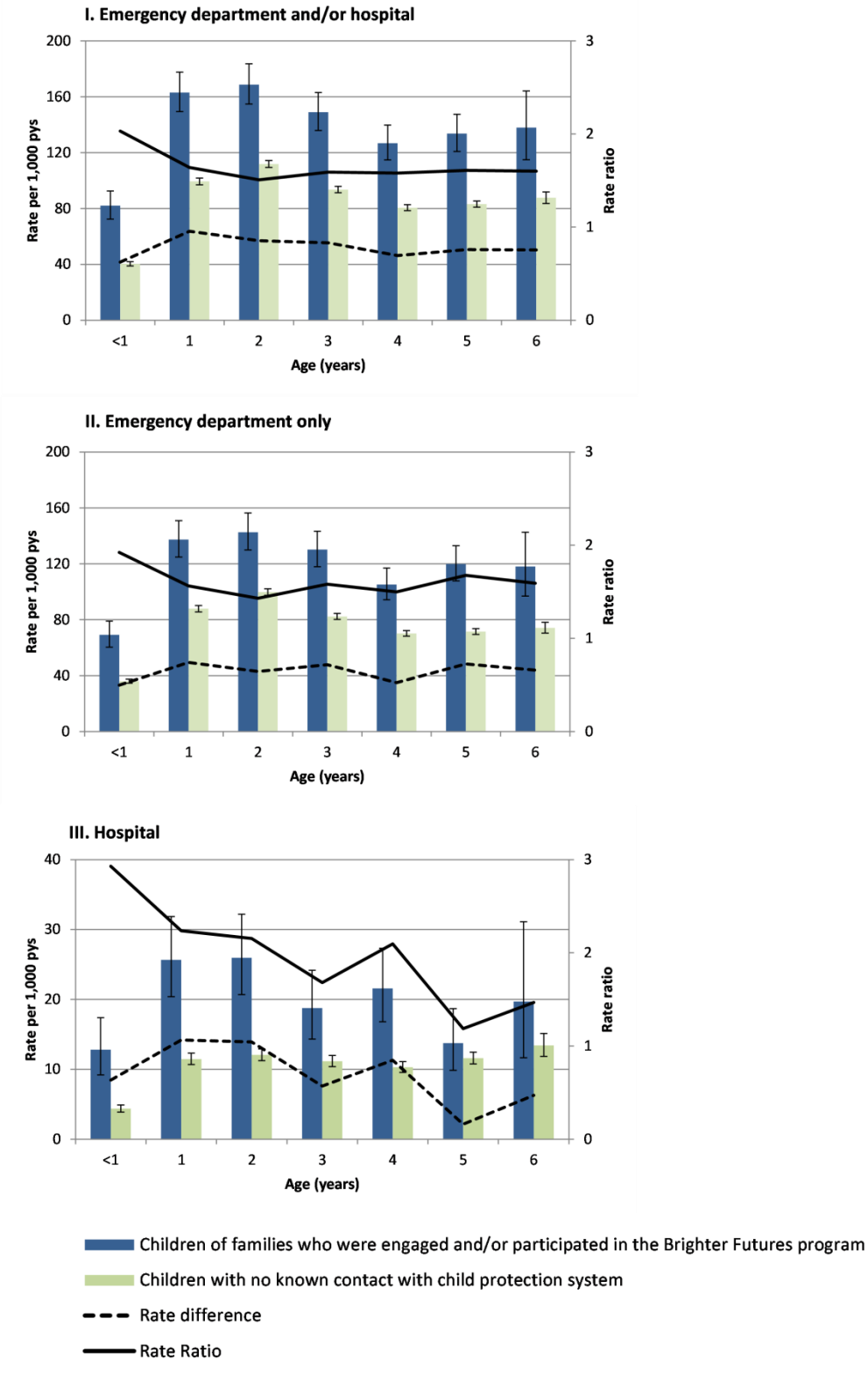
For each year of age between birth and six years, the rate difference for injury-related emergency department visits between children whose families were engaged and/or participated in the Brighter Futures program and children with no known contact with the child protection system ranged from 33 (95% CI 23-47) to 50 (95% CI 37-65) per 1,000 person years. The rate ratio of injury-related emergency department visits between children whose families were engaged and/or participated in the program and children with no known contact with the child protection system ranged from 1.4 to 1.9 across the age range (Appendix 6.1 Table 7).

3.6.1.3 Hospital admissions

Rates of injury related hospital admissions ranged from 13 per 1,000 person years (95%CI 9-17) to 26 per 1,000 person years (95% CI 21-32) across 1-year age groups between birth and six years of age in children whose families were engaged and/or participated in the Brighter Futures program. In children who had no contact with the child protection system during the study period, rates of injury-related emergency department visits and/or hospital admissions ranged from 4 per 1,000 person years (95% CI 4-5) to 13 per 1,000 person years (95% CI 12-15). Rates of injury-related hospital admissions peaked when children were two years old in children n who were engaged and/or participated in the Brighter Futures program and when children were six years old in children with no known contact with the child protection system during the study period (Figure 12, Appendix 6.1 Table 8).

For each year of age between birth and six years, the rate difference for injury-related hospital admissions between children whose families were engaged and/or participated in the Brighter Futures program and children with no known contact with the child protection system ranged from 6 (95% CI 2-13) to 14 (95% CI 8-24) per 1,000 person years. The rate ratio of injury related emergency hospital admissions between children whose families were engaged and/or participated in the program and children with no known contact with the child protection system ranged from 1.2 to 2.9 across the age range (Appendix 6.1 Table 8).

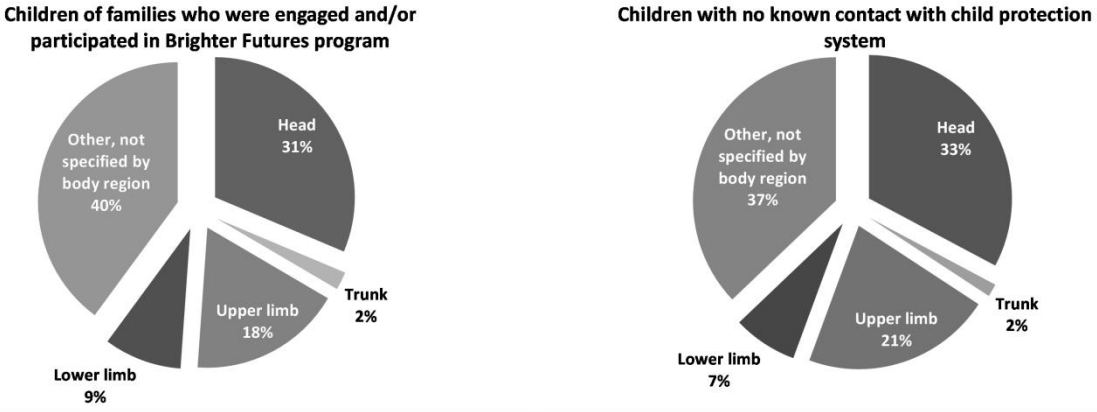
Figure 12: Rates of injury-related emergency department visits and/or hospital admissions between birth and the end of the child's first year of school for children whose families were engaged and/or participated in the Brighter Futures program compared with children with no known contact with the child protection system during the study period. I. Emergency department visits and/or hospital admission; II. Emergency department visits only; III. Hospital admissions.



3.6.2 Characteristics of injuries treated in the emergency department and/or hospital: main body regions affected and type of injury

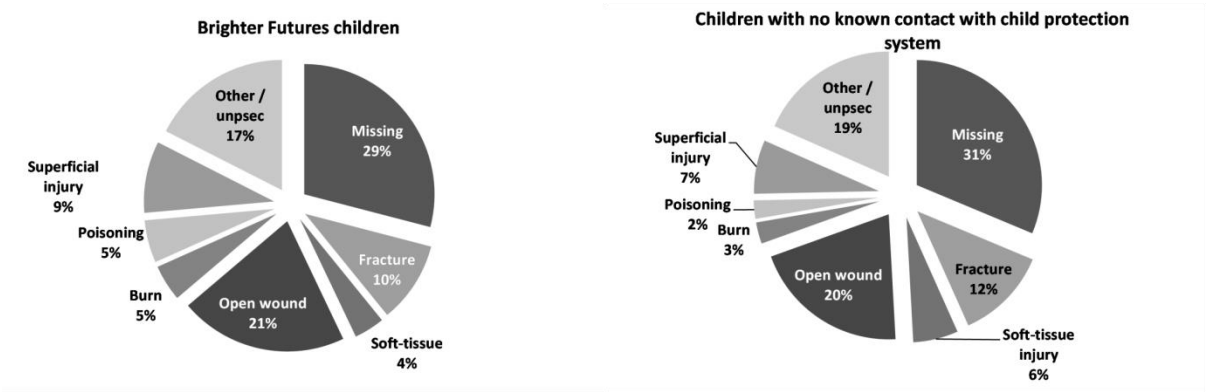
The most commonly injured body regions in both groups of children were the head and upper limb. Of children whose families were engaged and/or participated in the Brighter Futures program, 31% (n=853) were treated in the emergency department and/or hospital for a head injury and 18% (n=482) for an injury of the upper limb. In comparison, 33% (n=11,823) and 21% (n=7,733) of children who had no known contact with the child protection were treated for injuries to the head and upper limb, respectively (Figure 13).

Figure 13: The main body region injured as a percentage of all injury-related emergency department and/or hospital admissions among children of families who were engaged and/or participated in the Brighter Futures program compared with children with no known contact with the child protection system.



The leading types of injury treated in the emergency department and/or hospital in both groups of children were open wounds, contributing 21% (n=568) of all injury-related emergency department visits and/or hospital admissions in children whose families were engaged and/or participated in the Brighter Futures program, and 20% (n=7,357) in children with no known contact with the child protection system. Fractures and superficial injuries were the second and third leading types of injury, accounting for 10% (n=275) and 9% (n=242) of all injury-related emergency department visits and/or hospital admissions in children of families who were engaged and/or participated in the program, and 12% (n=4,338) and 7% (n=103) of injuries in children with no known contact with the child protection system, respectively. A higher percentage of children whose families were engaged and/or participated in the program were treated for burns (5%, n=123) and poisonings (5%, n=144) compared with children with no known contact with the child protection system (3%, n=1,000 and 2%, n=858, respectively) (Figure 14).

Figure 14: The types of injuries as a percentage of all injury-related emergency department and/or hospital admissions among children of families who were engaged and/or participated in the Brighter Futures program compared with children with no known contact with the child protection system.



3.7 Emergency department visits and/or hospital admissions for injury in children whose families participated in the Brighter Futures program.

Figure 15 presents rates of emergency department visits and/or hospital admissions for injury by age for children whose families participated in the program (henceforth referred to as Brighter Futures children), stratified by the child's age when the family first participated in the program, compared with children who had no known contact with the child protection system during the study period. After stratifying all Brighter Futures children into the age at first program participation groups, which resulted in 256-452 children per group, the numbers of emergency department visits and/or hospital admissions for injury in each 1-year age group were relatively small. As such, the confidence intervals around the rate estimates were wide and the results need to be interpreted taking these limitations into consideration (Appendix 6.1, Table 9).

Regardless of the child's age in the year their family first participated in the program, Brighter Futures children had higher rates of emergency department visits and/or hospital admissions for injury at all ages between birth and the end of their first year of school compared with children who had no known contact with the child protection system during the study period (Figure 15). In all age at first program participation groups, rates of injury-related emergency department visits and/or hospital admissions peaked when children were two years old, but the pattern of injury related emergency department visits and/or hospital admissions differed across the different age at first program participation groups.

3.7.1 Emergency department visits and/or hospital admissions rates in children whose families participated in the Brighter Futures program when the child was less than one year of age

For children whose families first participated in the program when they were less than one year of age (n=256), the rates of injuries treated in the emergency department and/or hospital ranged from 98 per 1,000 person years (95% CI 63-145) to 180 per 1,000 person years (95% CI 132-240) across the age range (Figure 15a, Appendix 6.1, Table 9).

Between birth and the end of the first year of school, the rate difference for injury-related emergency department visits and/or hospital admissions between children who were less than one year old when their families first participated in the Brighter Futures program and children with no known contact with the child protection system ranged from 28 (95% CI 18-40) to 76 (95% CI 60-95) per 1,000 person years. The rate ratio of injury-related emergency department visits and/or hospital admissions between children who were less than one year old when their families first participated in the program and children with no known contact with the child protection system ranged from 1.3 to 2.4 across the age range.

3.7.2 Emergency department visits and/or hospital admissions in children whose families participated in the Brighter Futures program when the child was one year of age

For children whose families first participated in the program when they were one year of age (n=383), the rates of injuries treated in the emergency department and/or hospital ranged from 73 per 1,000 person years (95% CI 49-106) to 191 per 1,000 person years (95% CI 150-240) across the age range (Figure 15b, Appendix 6.1, Table 9).

Between birth and the end of the first year of school, the rate difference for injury-related emergency department visits and/or hospital admissions between children who were one year old when their families first participated in the program and children with no known contact with the

child protection system ranged from 25 per 1,000 person years (95% CI 16-37) to 84 per 1,000 person years (95% CI 67-104). The rate ratio of injury related emergency department visits and/or hospital admissions between children who were one year old when their families first participated in the program and children with no known contact with the child protection system ranged from 1.3 to 1.9 across the age range.

3.7.3 Emergency department visits and/or hospital admissions in children whose families participated in the Brighter Futures program when the child was two years of age

For children whose families first participated in the program when they were two years of age (n=452), the rates of injuries treated in the emergency department and/or hospital ranged from 102 per 1,000 person years (95% CI 75-136) to 189 per 1,000 person years (95% CI 151-233) across the age range (Figure 15c, Appendix 6.1, Table 9)

Between birth and the end of the first year of school, the rate difference in injury-related emergency department visits and/or hospital admissions between children who were two years old when their families first participated in the Brighter Futures program and children with no known contact with the child protection system ranged from 41 per 1,000 person years (95% CI 30-56) to 80 per 1,000 person years (95% CI 63-100). The rate ratio of injury-related emergency department visits and/or hospital admissions between children who were two years old when their families first participated in the Brighter Futures program and children with no known contact with the child protection system ranged from 1.5 to 2.5 across the age range.

3.7.4 Emergency department visits and/or hospital admissions in children whose families participated in the Brighter Futures program when the child was three years of age

For children whose families first participated in the program when they were three years of age (n=365), the rates of injuries treated in the emergency department and/or hospital ranged from 69 per 1,000 person years (95% CI 44-101) to 200 per 1,000 person years (95% CI 157-252) across the age range. (Figure 15d, Appendix 6.1, Table 9).

Between birth and the end of the first year of school, the rate difference in injury-related emergency department visits and/or hospital admissions between children who were three years old when their families first participated in the program and children with no known contact with the child protection system ranged from 28 per 1,000 person years (95% CI 19-41) to 88 per 1,000 person years (95% CI 71-109). The rate ratio of injury-related emergency department visits and/or hospital admissions between children who were three years old when their families first participated in the program and children with no known contact with the child protection system ranged from 1.5 to 1.8 across the age range.

3.7.5 Emergency department visits and/or hospital admissions in children whose families participated in the Brighter Futures program when the child was four years of age

For children whose families first participated in the program when they were four years of age (n=350), the rates of injuries treated in the emergency department and/or hospital ranged from 63 per 1,000 person years (95% CI 39-95) to 129 per 1,000 person years (95% CI 94-172) across the age range (Figure 15e, Appendix 6.1, Table 9).

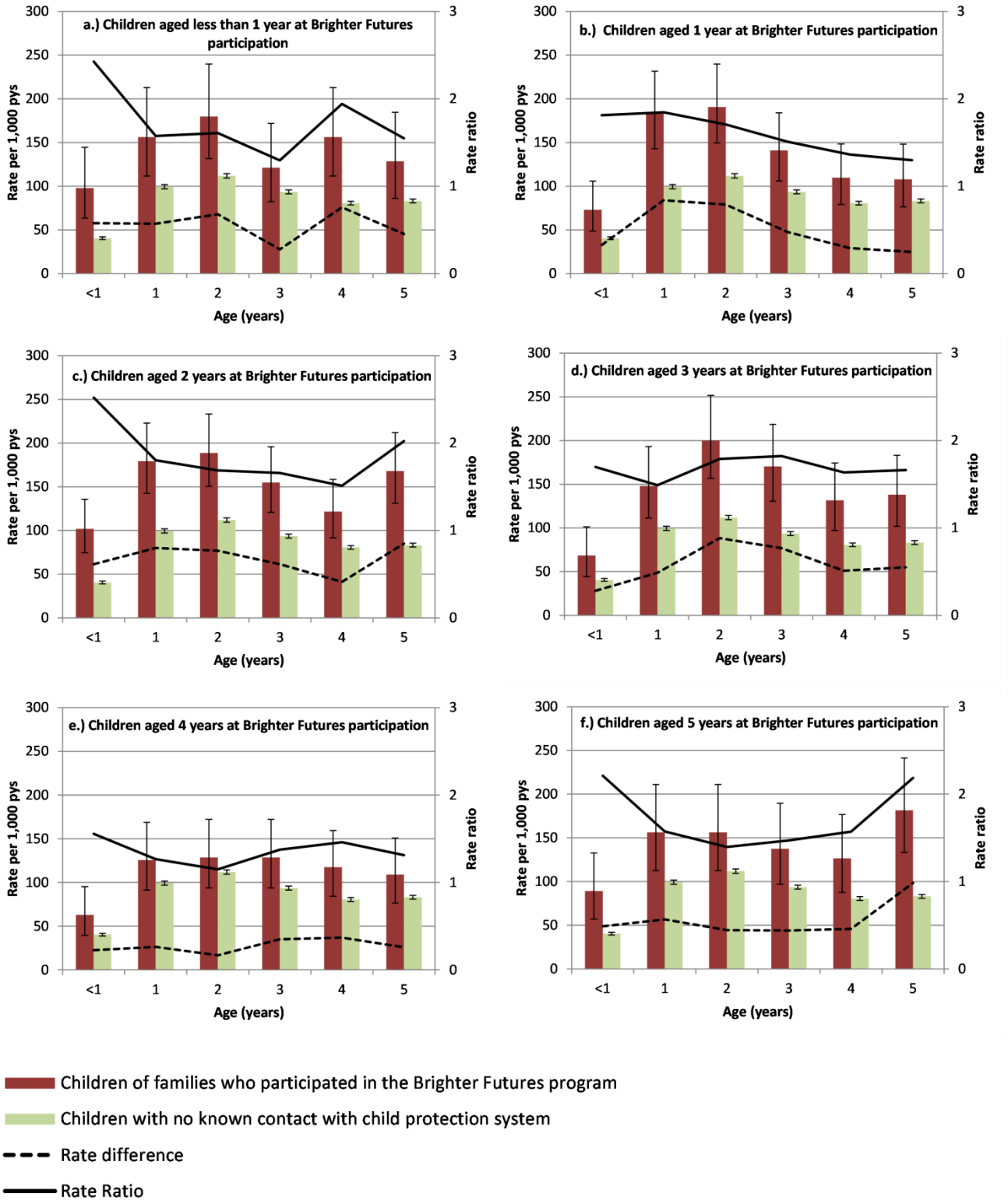
Between birth and the end of the first year of school, the rate difference in injury-related emergency department visits and/or hospital admissions between children who were four years old when their families first participated in the program and children with no known contact with the child protection system ranged from 17 per 1,000 person years (95% CI 10-27) to 37 per 1,000 person years (95% CI 26-51). The rate ratio of injury-related emergency department visits and/or hospital admissions between children who were four years old when their families first participated in the program and children with no known contact with the child protection system ranged from 1.3 to 1.6 across the age range.

3.7.6 Emergency department visits and/or hospital admissions in children whose families participated in the Brighter Futures program when the child was five years of age

For children whose families participated in the program when they were five years of age (n=269), the rates of injuries treated in the emergency department and/or hospital ranged from 89 per 1,000 person years (95% CI 57-133) to 182 per 1,000 person years (95% CI 133-241) across the age range (Figure 15f, Appendix 6.1, Table 9).

Between birth and the end of the first year of school, the rate difference in injury-related emergency department visits and/or hospital admissions between children who were five years old when their families first participated in the program and children with no known contact with the child protection system ranged from 44 per 1,000 person years (95% CI 32-59) to 98 per 1,000 person years (95% CI 80-120). The rate ratio of injury-related emergency department visits and/or hospital admissions between children who were five years old when their families first participated in the program and children with no known contact with the child protection system ranged from 1.4 to 2.2 across the age range.

Figure 15: Rates for emergency department visits and/or hospital admission for injury by age, stratified by the child's age when their family first participated in the Brighter Futures program*, compared with children with no known contact with the child protection system during early childhood.[#]



* Figure (a) to (f) represent the study's child age when the family first participated in the Brighter Futures program; 211 were aged less than 1 year, 305 were one year old, 408 were two years old, 310 were three years old, 233 were four years old and 226 were five years old when the family first participated in the program.

[#] The numbers of children and rates of injury in children with no known contact with the child protection system are the same in (a)-(f) for comparison with the general population.

4 SUMMARY AND CONCLUSION

4.1 Summary

Of the 80,952 children followed from birth to school age in this study, we identified 3,193 children whose families were engaged and/or participated in the Brighter Futures program between the child's birth and the end of their first year of school. The majority of these children (81%) had prior contact with the child protection system. A higher percentage of children whose families were engaged and/or participated in the program were Aboriginal, had low birth weight, were born prematurely, had special needs and lived in remote and disadvantaged areas compared with children with no known contact with the child protection system during the study period. The mothers of Brighter Futures children were younger, fewer were married and more smoked during pregnancy compared with mothers of children with no known contact with the child protection system during the study period. During early childhood, the 3,193 children of families who were engaged and/or participated in the program had a total of 2,727 emergency department visits and/or hospital admissions for injury. The majority of these injuries were treated in the emergency department only (85.5%), and 14.5% were treated in the hospital. Children of families who were engaged and/or participated in the program had significantly higher rates of emergency department visits and/or hospital admissions for injury at all ages compared with children with no known contact with the child protection system during the study period, although the pattern of injury rates from birth to school age was similar in both groups. Rates of injury-related emergency department visits and/or hospital admissions peaked when children were two years old and were lowest in their first year of life; as such the absolute and relative inequalities in injury events between children who were engaged and/or participated in the program compared with children with no known contact with the child protection system during the study period were similar across all age groups. When injury rates were examined in relation to the child's age when their family first participated in the program, there were no clear patterns of injury-related emergency department visits and/or hospital admissions in relation to the child's age when the family first participated in the program.

Our finding that children whose families were engaged and/or participated in the Brighter Futures program were more disadvantaged, had worse measures of health-related outcomes and exposures from birth, and were less likely to participate in preschool before starting school compared with children with no known contact with the child protection system during the study period is consistent with the program's aim to target vulnerable families. Through cross-sectoral data integration, this study extends upon findings from a previous evaluation of families who participated in Brighter Futures in earlier years of the program (2007-2009). Data collected as part of this previous evaluation characterised families as disadvantaged and vulnerable, but there was little information on early life health outcomes and exposures.[27] The clustering of disadvantage and adverse early life outcomes and exposures in children whose families were engaged and/or participated in the program is also consistent with findings from other studies of children who were the subject of abuse or neglect allegations in other populations.[24]

Our analysis showed that most children (82%) had been known to the child protection system before their families were considered for participation in the Brighter Futures program. These findings are consistent with an earlier evaluation of the program in 2007-2009,[32] which showed that 80% of children had contact with the child protection system prior to their families entering the program. Although the Brighter Futures program aimed to target vulnerable families in order to prevent them from escalating in the child protection system during the period of this study, linkage of longitudinal child protection report and OOHC data in this study revealed that some children whose families were considered for participation for Brighter Futures had complex child protection histories, with multiple previous child protection reports, substantiated child protection reports, and in some cases,

OOHC placements, before first contact with the program.

Our findings that rates of injury treated in the emergency department and/or hospital were higher across all ages from birth to six years old in children whose families were engaged and/or participated in the Brighter Futures program compared with children with no known contact with the child protection system during early childhood are broadly consistent with findings from previous studies of children who were the subject of child abuse and/or neglect allegations in other populations.[9,11,13] Although the majority of children in our study had at least one child abuse and/or neglect allegation before their families were engaged and/or participated in the program, 27% of children had no known contact with the child protection system that we could ascertain from the study data. However, Brighter Futures aimed to target families who were considered to be at risk of entering, or escalating within, the child protection system at the time of this study. Previous studies from Western Australia and the US showed that children with child abuse or neglect allegations were more likely to have had a prior emergency department visit or hospitalisation for injury.[9,11] Another study from California in the US showed that children with prior child abuse or neglect allegations had higher rates of deaths from intentional and unintentional injuries compared with children who had no prior child protection report.[13] To our knowledge, the Californian study[13] is the only population-based study of children who were the subject of child abuse and/or neglect allegations thus far that has differentiated between hospitalised unintentional and intentional injury. We were unable to distinguish between intentional and unintentional injuries in the emergency department data in this study. Because the majority of injuries were treated in the emergency department in our study population (86%) and only 14% required hospitalisation, we have not distinguished between intentional and unintentional injuries in this analysis.

The main types of injury treated in the emergency department and/or hospital for children in this study were open wounds, fractures and superficial injuries, and the main body regions affected were the head, the upper limb and the lower limb. Although the leading types of injury and body regions affected by injury were similar in both groups of children, a slightly higher proportion of children whose families were engaged and/or participated in the Brighter Futures program were treated for burns and poisonings. Compared with the leading types of hospitalised injury among young children nationally,[1] we observed a smaller proportion of fractures in our study. However, we examined emergency department visits and hospitalisations in this study, and the majority of injuries presented to the emergency department only. As such, we are unable to make a direct comparison of the distribution of injury type in our study with national hospital data. The main body regions affected by injury observed in our study are in line with those reported for hospitalised injuries in 1-4 year olds in Australia.[1] However, the proportions of head, and upper and lower limb injuries were lower in this study compared with national hospital data, which is also likely to be related to the analysis of emergency department visits in addition to hospitalisations in this study.

This study is the first to examine early childhood outcomes for children whose families were engaged and/or participated in the Brighter Futures program beyond the core aims of preventing families from entering, or escalating, in the NSW child protection system, which was the subject of an earlier evaluation.[27] Because of the established association between child abuse and/or neglect reports and child injury outcomes, this study aimed to assess rates of injury-related emergency department visits and/or hospitalisations before and after children's families participated in the program. Although the Brighter Futures program is not an injury prevention program, it addresses many of the risk factors that are common to both child injury and child abuse and/or neglect, such as family functioning and parenting.[31] Although there was variation in the absolute injury inequalities between Brighter Futures children and those with no known contact with the child protection system during early

childhood, we were unable to detect any significant trends in relation to the year the family first participated in the program. After stratifying the study population by the age of the study child when their family first participated in the program, the numbers of injury events per year of age in each group were small, and 95% confidence intervals were wide, which limited our ability to detect changes in the inequalities across age groups. However, this analysis shows that there is scope to reduce the gap in child injury between Brighter Futures children and the general child population throughout early childhood.

In addition to describing the injury experience of Brighter Futures children during early childhood, we also assessed the feasibility of applying quasi-experimental methodologies to the Seeding Success data resource to assess the impact of the program on child outcomes, such as injury. The summary of the findings, described in Appendix 6.2, highlights some important considerations and challenges in the application of propensity score matching to identify a comparison group of children with similar characteristics to the children whose families participated in the program between birth and school age. Although the application of propensity score matching methods identified comparison groups that were similar to the Brighter Futures children based on measured characteristics available in the data resource, the estimates of the program effect on child development outcomes did not differ substantively from results based on a crude comparison of treated and all untreated children in the general population. This suggests that there may be barriers to applying this quasi-experimental approach, and isolating the effect of the treatment, in this context.

4.2 Strengths and Limitations

To our knowledge, this is the first study to demonstrate the burden of serious injury – measured as injuries treated in emergency departments and/or hospitals in NSW – among children whose families were engaged and/or participated in the Brighter Futures program. A major strength of this study was the large sample size. For the first time in NSW, this study linked data from seven population data sources collected by agencies responsible for services relating to birth, health, community services, and education, for an almost complete population of school starters in 2012.This novel data resource enabled us to make visible the early life injury experience of a small and vulnerable population of children in contact with the child protection system in NSW, and highlight the potential for delivering injury prevention measures as part of an existing broad-based early intervention program for vulnerable families at risk of entering the child protection system in NSW. Moreover, we were able to characterise this large population of children and their families across a range of demographic, health and child development measures, as well as examine child protection histories prior to Brighter Futures program participation, through integration of cross-sectoral data sources.

Some limitations of the study should be considered. A limitation was the quality of recording of the primary diagnosis and the use of different coding systems in the emergency department data. The NSW EDDC records the primary diagnosis at presentation according to the ICD-9-CM[41], ICD-10-AM[39] International Statistical Classifications of Diseases and Related Health Problems and the Systematised Nomenclature of Medicine, Clinical Terms SMOMED -CT-AU terminology.[42] SNOMED is not organised in the same hierarchical structure as the ICD classification and the concept injury also includes medical conditions such as gangrenous disorders, haemorrhagic disorders of intestines, and necrosis of flap, which are not classified as injuries in the ICD classification. At this time, the best way to apply a standardised approach to identifying injuries in the EDDC was to map SNOMED to ICD-10 codes. A similar approach has been used in the analysis of emergency data at the national level in

Australia.[53] However, this approach risks loss of information in the mapping process, or incorrect identification of some injuries. Another limitation of analysing injury using the EDDC is incomplete recording of diagnosis codes. For the analysis of types of injury and body region affected, ICD-9-CM codes were mapped forward to ICD-10-AM. In this analysis, 9% of ICD-9-CM codes that were identified as injuries did not map to ICD-10-AM because of incomplete recording of the ICD-9-CM codes in the EDDC. These were captured in the category "missing" in the analysis of body region and type of injury. Similarly, national analysis of emergency data showed that 17% of ICD-9 codes were incomplete and did not map to ICD-10-AM codes in the analysis.[53] Although we were able to classify hospital admissions for injury as intentional or unintentional, we were unable to distinguish between intentional and unintentional injuries in the EDDC. However, it can be difficult for clinicians to differentiate between intentional and unintentional injuries in the clinical setting, and it is likely that some injuries are misclassified in the medical records.[54]

Although the Brighter Futures program commenced in 2003/4, electronic data on program participation are only available from 2007 onwards. This limited us to following the 2012 school starter cohort only because we were unable to ascertain program participation in the early years of life for children in the 2009 school starter cohort in the Seeding Success study data resource. Restricting the study population to the 2012 school starter cohort almost halved the number of children in the study population, thereby reducing our statistical power to detect differences between Brighter Futures children and children in the general population, or the propensity score matched comparison group.

Another challenge of interpreting the source data in this study stems from the change in the threshold for mandated child protection reports in January 2010; at this time, the threshold was increased from 'risk of harm' to 'risk of significant harm'.[43] As a consequence, the characteristics of families who entered the Brighter Futures program through child protection helpline reports after 2010 may have differed to f those of families who entered the program before 2010. Furthermore, a different number of child protection reports in children older than 2-3 years, the age of most children when the threshold changed, do not necessarily reflect a difference in the true risks for children in the study population; however, the impact of the change of threshold can not be clearly disentangled from any true changes in risks.

Finally, we were limited by the variables and the pool of untreated children available for propensity score matching in the source data. The power of propensity score matching to correct for non-random allocation is limited to the suitability of the underlying covariate information: in this study child, family and area-level variables available in the Seeding success data resource were used, including a mixture of demographic and early life health and development variables, and some information on child protection notifications. Although we achieved balance between the treated and untreated groups on measured characteristics available in the data resource, the estimates of the program effect on child development outcomes did not differ substantively from results based on a crude comparison of treated and all untreated children in the general population. It may be possible to get a better estimate of the Brighter Futures treatment effect if more of the markers of extreme disadvantage—domestic violence, drug or alcohol misuse, mental health issues, lack of parenting skills— that are experienced by Brighter Futures families were able to be identified from population data sets. However, information about these vulnerabilities is complex to identify in the source data, and at best only partially available, at this time. Another key challenge in identifying a comparison group is the remaining pool of untreated children in the population. For example, if the program participants were consistently the most at-risk cases it is possible that there were few or no equivalent cases remaining in the pool of untreated children. The third major challenge to overcome

in this study was that the child's age at first program participation was variable; to address this, we stratified by age at first program participation prior to matching, but this greatly reduced the sample size in each strata and increased uncertainty around estimates of effect.

4.3 Conclusions and implications

The higher rates of injury-related emergency department visits and/or hospitalisations across all ages from birth to six years among children whose families were engaged and/or participated in the Brighter Futures program compared with children in the general population suggest there is scope to reduce injury in this vulnerable population. The underlying causes of child abuse and/or neglect and child injury are complex, and a number of interlinked factors at different levels (e.g. child, family, and environment) may contribute to their occurrence and severity of the problem.[24,55,56] Early life disadvantage is a common underlying risk for both child abuse and/or neglect[24] and child injury.[4] A widely used model to illustrate the relationship between the individual, their environment and health is the model of the social determinants of health.[57,58] The social determinants of health may impact on injuries through a variety of pathways, such as risks and hazards in the community and home environment, stress caused by poverty and social exclusion, and access to safety equipment, services and education.[56,59] For example disadvantaged families may have less resources to protect their children from injury[65,66] and children may be exposed to a wider range of hazards in the living environment.[4] In poorer households, parents may have less time to supervise their children because of competing demands, may not be able to afford safety equipment and they may live in overcrowded houses with lack of space for safe play.[17,60-62] Access to injury prevention programs and knowledge of safety measures may also be lower in disadvantaged populations, [18,23] and they may live in neighbourhoods that pose a higher risk to child injuries because of less safe areas for play.[17]

International evidence shows that broad-based early childhood programs can be successful in delivering safety messages and interventions to vulnerable families who may be otherwise difficult to engage in injury prevention.[22,63] As such, the addition of multifaceted injury prevention measures to the suite of existing support services offered to Brighter Futures families may represent one opportunity to reduce injuries in vulnerable children already known to child protection services in NSW. Locally, an evaluation of the Illawarra Aboriginal Medical Service "Safe Homes Safe Kids" program found that provision of home safety advice and free home safety devices not only had a positive impact on child safety in Aboriginal families with young children, but also helped to establish contact with vulnerable families before offering wider support services.[64] More broadly, key facilitators of injury prevention measures have been identified as strong legislation, design of focused and simple programs with a clear message, promotion of safety measures which are simple to implement, provision of free or low cost safety equipment, community involvement, and delivery by a professional trusted by the family.[65,66]

The results from the propensity score matching scoping analysis highlighted some key challenges in retrospectively constructing a control group to estimate the effect of a program that was rolled out in the 'real world' in a non-random fashion. The difficulties in retrospectively constructing a valid comparison group, despite the linkage of multiple population datasets and the application of advanced epidemiological and statistical methods, emphasises the importance of designing program evaluation methods, including study design and data collection, before the implementation of new programs and services.

4.4 Comments regarding future research opportunities

The majority of children of families who were engaged and/or participated in Brighter Futures had previous contact with the child protection system. Using the available Seeding Success data resource, future research could investigate the injury experience of all children who become known to the child protection system in NSW during early childhood. For example, there exists the opportunity to learn more about the patterns of presentations to emergency departments and admissions to hospital in the lead up to child protection reports. Are children reported to child protection likely to present to different hospitals for multiple injuries, and if so, what are their characteristics and health service use patterns that might inform earlier identification and intervention for these children that would reduce their future injury risk?

The Seeding Success data resource is an exemplar of how cross-sectoral population data can be joined up in NSW to reveal the early life health and development experience of children in contact with different systems, including health, child protection, and education. Using these data we were able to identify more than 2,000 children whose families participated in an early intervention program from a cohort of more than 80,000 school starters followed from birth to school age. Yet there was limited statistical power to detect changes in outcomes that may be associated with program participation once program participants were stratified in groups according to the year they started the program. Future investment in an up-scaled cross-sectoral population data resource that incorporates all birth cohorts of children born in NSW, and followed over time, would offer the opportunity to follow all children who participated in Brighter Futures, as well as other early intervention programs, in NSW. This would afford larger numbers of children and greater statistical power to detect changes in outcomes associated with program participation. Furthermore, incorporation of other key data sources, such as police reports, and collection of key characteristics of vulnerable children and their families not currently available in the population data, may improve the opportunity to apply quasi-experimental methodologies to learn more about the impact of programs and services in NSW.

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6 APPENDIX

6.1 Additional Tables

Table 6: Number and rates of injury-related emergency department visits and/or hospital admissions between birth and the end of the child's first year of school for children whose families were engaged and/or participated in the Brighter Futures program compared with children with no known contact with the child protection system during the study period.

	Brighter Futures engagement and/or participation					**No known contact with protection system**					**Rate Difference and Rate Ratios**					
Age	Number injuries	Person years	Rate	Lower 95% CI	Upper 95% CI	Number injuries	Person years	Rate	Lower 95% CI	Upper 95% CI	Rate difference	Lower 95% CI	Upper 95% CI	Rate Ratio	Lower 95% CI	Upper 95% CI
0	262	3196	82.0	72.4	92.5	2755	68242	40.4	38.9	41.9	41.6	29.9	56.3	2.0	1.8	2.3
1	521	3196	163.0	149.3	177.6	6778	68242	99.3	97.0	101.7	63.7	49.0	81.4	1.6	1.5	1.8
2	539	3196	168.6	154.7	183.5	7629	68242	111.8	109.3	114.3	56.9	43.0	73.7	1.5	1.4	1.6
3	476	3196	148.9	135.9	162.9	6380	68242	93.5	91.2	95.8	55.4	41.8	72.1	1.6	1.4	1.7
4	405	3196	126.7	114.7	139.7	5492	68240	80.5	78.4	82.6	46.2	33.9	61.6	1.6	1.4	1.7
5	398	2979	133.6	120.8	147.4	5348	64376	83.1	80.9	85.3	50.5	37.6	66.5	1.6	1.4	1.8
6	126	914	137.8	114.8	164.1	1718	19609	87.6	83.5	91.9	50.2	37.3	66.2	1.6	1.3	1.9

Table 7: Number and rates of injury-related emergency department visits between birth and the end of the child's first year of school for children whose families were engaged and/or participated in the Brighter Futures program compared with children with no known contact with the child protection system during the study period.

	Brighter Futures engagement and/or participation					**No known contact with protection system**					**Rate Difference and Rate Ratios**					
Age	Number injuries	Person years	Rate	Lower 95% CI	Upper 95% CI	Number injuries	Person years	Rate	Lower 95% CI	Upper 95% CI	Rate difference	Lower 95% CI	Upper 95% CI	Rate Ratio	Lower 95% CI	Upper 95% CI
0	221	3196	69.1	60.3	78.9	2456.0	68242	36.0	34.6	37.4	33.2	22.8	46.5	1.9	1.7	2.2
1	439	3196	137.4	124.8	150.8	5995.0	68242	87.8	85.6	90.1	49.5	36.7	65.4	1.6	1.4	1.7
2	456	3196	142.7	129.9	156.4	6806.0	68242	99.7	97.4	102.1	42.9	31.1	57.9	1.4	1.3	1.6
3	416	3196	130.2	118.0	143.3	5618.0	68242	82.3	80.2	84.5	47.8	35.3	63.5	1.6	1.4	1.8
4	336	3196	105.1	94.2	117.0	4789.0	68240	70.2	68.2	72.2	35.0	24.3	48.6	1.5	1.3	1.7
5	357	2979	119.8	107.7	132.9	4601.0	64376	71.5	69.4	73.6	48.4	35.7	64.1	1.7	1.5	1.9
6	108	914	118.1	96.9	142.6	1455.0	19609	74.2	70.4	78.1	43.9	31.9	59.0	1.6	1.3	1.9

Table 8: Number and rates of injury-related hospital admissions between birth and the end of the child's first year of school for children whose families were engaged and/or participated in the Brighter Futures program compared with children with no known contact with the child protection system during the study period.

	Brighter Futures engagement and/or participation					**No known contact with protection system**					**Rate Difference and Rate Ratios**					
Age	Number injuries	Person years	Rate	Lower 95% CI	Upper 95% CI	Number injuries	Person years	Rate	Lower 95% CI	Upper 95% CI	Rate difference	Lower 95% CI	Upper 95% CI	Rate Ratio	Lower 95% CI	Upper 95% CI
0	41	3196	12.8	9.2	17.4	299	68242	4.4	3.9	4.9	8.4	3.7	16.4	2.9	2.1	4.1
1	82	3196	25.7	20.4	31.8	783	68242	11.5	10.7	12.3	14.2	7.8	23.7	2.2	1.8	2.8
2	83	3196	26.0	20.7	32.2	823	68242	12.1	11.3	12.9	13.9	7.6	23.4	2.2	1.7	2.7
3	60	3196	18.8	14.3	24.2	762	68242	11.2	10.4	12.0	7.6	3.2	15.2	1.7	1.3	2.2
4	69	3196	21.6	16.8	27.3	703	68240	10.3	9.6	11.1	11.3	5.7	20.1	2.1	1.6	2.7
5	41	2979	13.8	9.9	18.7	747	64376	11.6	10.8	12.5	2.2	0.3	7.5	1.2	0.8	1.6
6	18	914	19.7	11.7	31.1	263	19609	13.4	11.8	15.1	6.3	2.4	13.4	1.5	0.9	2.4

Table 9: Number and rates for emergency department visits and/or hospital admission for injury by age, stratified by the child's age when their family first participated in the Brighter Futures program, compared with children with no known contact with the child protection system during early childhood.

Brighter Futures							**No child protection record**					**Rate Difference and Rate Ratios**					
Age at Brighter Futures start	Age	Number injuries	Person years	Rate	Lower 95% CI	Upper 95% CI	Number injuries	Person years	Rate	Lower 95% CI	Upper 95% CI	Rate difference	Lower 95% CI	Upper 95% CI	Rate Ratio	Lower 95% CI	Upper 95% CI
0	0	25	255.3	97.9	63.4	144.6	2755	68242	40.4	38.9	41.9	57.6	43.7	74.5	2.43	1.57	3.59
0	1	40	256.0	156.3	111.6	212.8	6778	68242	99.3	97.0	101.7	56.9	43.1	73.8	1.57	1.12	2.14
0	2	46	256.0	179.7	131.6	239.7	7629	68242	111.8	109.3	114.3	67.9	52.7	86.1	1.61	1.18	2.15
0	3	31	256.0	121.1	82.3	171.9	6380	68242	93.5	91.2	95.8	27.6	18.3	40.0	1.29	0.88	1.84
0	4	40	256.0	156.2	111.6	212.8	5492	68240	80.5	78.4	82.6	75.8	59.7	94.9	1.94	1.39	2.65
0	5	29	225.8	128.4	86.0	184.5	5348	64376	83.1	80.9	85.3	45.4	33.1	60.6	1.55	1.03	2.22
1	0	28	383.0	73.1	48.6	105.7	2755	68242	40.4	38.9	41.9	32.7	22.5	46.0	1.81	1.20	2.62
1	1	70	382.0	183.3	142.9	231.5	6778	68242	99.3	97.0	101.7	83.9	67.0	103.9	1.85	1.44	2.33
1	2	73	383.0	190.6	149.4	239.7	7629	68242	111.8	109.3	114.3	78.8	62.4	98.2	1.71	1.34	2.15
1	3	54	383.0	141.0	105.9	184.0	6380	68242	93.5	91.2	95.8	47.5	35.0	63.1	1.51	1.13	1.97
1	4	42	383.0	109.7	79.0	148.2	5492	68240	80.5	78.4	82.6	29.2	19.6	41.9	1.36	0.98	1.84
1	5	38	352.4	107.8	76.3	148.0	5348	64376	83.1	80.9	85.3	24.8	16.0	36.6	1.30	0.92	1.78
2	0	46	452.0	101.8	74.5	135.7	2755	68242	40.4	38.9	41.9	61.4	47.0	78.8	2.52	1.84	3.37
2	1	81	452.0	179.2	142.3	222.7	6778	68242	99.3	97.0	101.7	79.9	63.3	99.4	1.80	1.43	2.25
2	2	85	450.8	188.6	150.6	233.2	7629	68242	111.8	109.3	114.3	76.8	60.6	96.0	1.69	1.35	2.09
2	3	70	452.0	154.9	120.7	195.7	6380	68242	93.5	91.2	95.8	61.4	47.0	78.8	1.66	1.29	2.09
2	4	55	452.0	121.7	91.7	158.4	5492	68240	80.5	78.4	82.6	41.2	29.6	55.9	1.51	1.14	1.97
2	5	71	422.6	168.0	131.2	211.9	5348	64376	83.1	80.9	85.3	84.9	67.8	105.0	2.02	1.58	2.56
3	0	25	365.0	68.5	44.3	101.1	2755	68242	40.4	38.9	41.9	28.1	18.7	40.6	1.70	1.10	2.51
3	1	54	365.0	147.9	111.1	193.0	6778	68242	99.3	97.0	101.7	48.6	35.9	64.4	1.49	1.12	1.95
3	2	73	365.0	200.0	156.8	251.5	7629	68242	111.8	109.3	114.3	88.2	70.8	108.6	1.79	1.40	2.25
3	3	62	364.0	170.3	130.6	218.4	6380	68242	93.5	91.2	95.8	76.8	60.6	96.1	1.82	1.39	2.34
3	4	48	365.0	131.5	97.0	174.4	5492	68240	80.5	78.4	82.6	51.0	38.0	67.1	1.63	1.20	2.17
3	5	48	347.8	138.0	101.7	183.0	5348	64376	83.1	80.9	85.3	54.9	41.4	71.5	1.66	1.22	2.21

Table 9 continued: Number and rates for emergency department visits and/or hospital admission for injury by age, stratified by the child's age when their family first participated in the Brighter Futures program, compared with children with no known contact with the child protection system during early childhood.

Brighter Futures							**No child protection record**					**Rate Difference and Rate Ratios**					
Age at Brighter Futures start	Age	Number injuries	Person years	Rate	Lower 95% CI	Upper 95% CI	Number injuries	Person years	Rate	Lower 95% CI	Upper 95% CI	Rate difference	Lower 95% CI	Upper 95% CI	Rate Ratio	Lower 95% CI	Upper 95% CI
4	1	44	350.0	125.7	91.3	168.8	6778	68242	99.3	97.0	101.7	26.4	17.3	38.6	1.27	0.92	1.70
4	2	45	350.0	128.6	93.8	172.0	7629	68242	111.8	109.3	114.3	16.8	9.7	26.9	1.15	0.84	1.54
4	3	45	350.0	128.6	93.8	172.0	6380	68242	93.5	91.2	95.8	35.1	24.4	48.8	1.37	1.00	1.84
4	4	41	349.0	117.5	84.3	159.4	5492	68240	80.5	78.4	82.6	37.0	26.0	51.0	1.46	1.05	1.98
4	5	36	330.4	109.0	76.3	150.8	5348	64376	83.1	80.9	85.3	25.9	16.9	38.0	1.31	0.92	1.82
5	0	24	269.0	89.2	57.2	132.8	2755	68242	40.4	38.9	41.9	48.8	36.1	64.6	2.21	1.41	3.30
5	1	42	269.0	156.1	112.5	211.0	6778	68242	99.3	97.0	101.7	56.8	43.0	73.6	1.57	1.13	2.13
5	2	42	269.0	156.1	112.5	211.0	7629	68242	111.8	109.3	114.3	44.3	32.3	59.5	1.40	1.01	1.89
5	3	37	269.0	137.5	96.8	189.6	6380	68242	93.5	91.2	95.8	44.1	32.0	59.1	1.47	1.03	2.03
5	4	34	269.0	126.4	87.5	176.6	5492	68240	80.5	78.4	82.6	45.9	33.6	61.3	1.57	1.09	2.20
5	5	47	258.9	181.5	133.4	241.4	5348	64376	83.1	80.9	85.3	98.4	80.0	119.9	2.18	1.60	2.91

6.2 Propensity score matching scoping analysis for a quasi-experimental study to assess the impact of the Brighter Futures program on child outcomes.

6.2.1 Overview

Propensity score matching is a statistical approach that can be applied in quasi-experimental studies to estimate causal treatment effects in the absence of a randomised controlled trial (RCT) study design.[44] In the case of the Brighter Futures program, which was rolled out in New South Wales in a non-random fashion in 2003/4, the best opportunity to estimate its effect now lies with quasi-experimental methodologies applied to linked, cross-sectoral population data. The Seeding Success data resource offers a new opportunity to trial such a design: the study population includes two school starter cohorts who were enrolled in Kindergarten in NSW in 2009 and 2012, with child outcomes currently obtained until the end of their first year in fulltime schooling, and linked to Brighter Futures program data that includes information on engagement[1] and program participation from 2007, coinciding with the entire early childhood period for children who started school in 2012. The linked population datasets within the Seeding Success data resource offer a rich set of child, family and area-level information that is necessary for implementing propensity score matching to identify the best possible comparison group for a quasi-experimental study.

We performed a series of scoping analyses to explore the plausibility of implementing propensity score matching to identify a comparison group of children who had similar characteristics to the children whose families participated in Brighter Futures. The methods and results for these analyse are described in this appendix. We also provide some background information on the propensity score matching methodology (Section 6.2.2), and discuss some of the questions that arose in the context of applying propensity score matching to assess the impact of the Brighter Futures program (Section 6.2.3). Section 6.2.4 describes the methods used in the scoping analysis; the results are presented in Section 6.2.5. The conclusions and implications are discussed in Section 6.

6.2.2 Background: propensity score matching

6.2.2.1 Randomised controlled trials versus quasi-experimental methodologies

Randomised controlled trials (RCTs) are considered the gold standard experimental design to assess the effectiveness of a treatment or program. Under this design, study participants are randomly assigned to either receive the treatment under study, or to a control group who receives an alternative treatment, or no treatment at all. To avoid placebo effects and other biases, ideally both the study participants and investigators will be unaware of group membership, thus making the trial "double blind".

RCTs are appealing because, when conducted correctly, the true effect of a treatment becomes relatively easy to estimate. The purpose of randomisation is to ensure that treated and control groups are equal, on average, in terms of key measured and unmeasured characteristics of the participants, which may be related to the outcome of interest. As a result, the only meaningful difference between the two groups is whether or not the treatment was received, and therefore, any differences in outcomes between the two groups can be ascribed to the treatment.

[1] As in the main report, engagement here refers to the initial phase during which the Department of Family and Community Services approaches a family to assess whether or not they are eligible for the program, and the family decides whether or not they want to participate.

Although RCTs are considered the gold standard, implementing RCTs is not always practical, feasible or ethical. Formal experimental studies require considerable advance planning, can be costly to design and administer, and can also raises ethical questions if randomisation results in a potentially beneficial treatment being withheld from an individual in need. When programs or treatments are rolled out in the absence of an RCT, it becomes more difficult to estimate the true effect of an intervention because it is no longer necessarily true that individuals receiving the treatment are the same, on average, to a non-randomised control group who did not. As a result, observed differences in outcomes between treated and untreated groups may be due to pre-existing differences in the measured and unmeasured characteristics of individuals, rather than the treatment being studied. For example, the positive effect of a new medication might be masked if the medication is more often assigned to sicker individuals.

Quasi-experimental study designs present the next best opportunity to evaluate a treatment effect in the absence of formally randomised controlled designs.[67] There are many approaches to identifying a suitable 'control' group that fall under the quasi-experimental methodology umbrella, including propensity score matching. The core premise of propensity score matching is to use observational data to simulate the balance between treated and control groups, which would have been achieved by randomisation. As a simple illustration of the concept, let's suppose age and sex was known for a population of individuals, some of who received a treatment of interest. One approach to estimate the effect of the treatment would be to select a control group in such a way that the distribution of age and sex matched that of the treated group. The analysis could then proceed as if randomisation had taken place, and results in the control group could be compared directly to results in the treated group.

Matching treated and untreated individuals on age and sex alone is unlikely to produce an ideal comparison group; it is desirable to match on many more characteristics in order to construct a control group that is, on average, equal in terms of key baseline characteristics. However, as the number of variables available to match on grows, the exercise of matching each treated individual to an equivalent untreated individual becomes increasing difficult. For example, it may be difficult to find an exact match for individuals with a rare combination of characteristics. Propensity score matching is an approach that attempts to overcome this problem. Rather than matching groups on a large set of characteristics, the available covariate information can be combined into a single measure, or dimension, and matches can be based on that measure. In this context, the measure generated is an individual's propensity score: an estimate of the probability of receiving the treatment being studied. Propensity scores can be estimated using observational data, by comparing the characteristics of individuals who did and did not get treated. In practice, this is done by fitting a logistic regression model to a dichotomous variable indicating whether or not the treatment was received. Foundational work in this area[68] has shown that matching on composite propensity scores, rather than the individual variables, is sufficient to remove the bias caused by treated and untreated groups differing in terms of those variables.

Estimated propensity scores need to satisfy certain conditions to be considered valid. Foremost amongst these are the conditions of (i) common support and (ii) balance.[69] Propensity scores have common support if the probabilities of treatment overlap for treated and untreated individuals. The range of estimated probabilities observed in both groups is referred to as the region of common support. If there is no overlap in the scores—if all treated individuals have a very high propensity and all untreated individuals have a very low propensity—then creating a valid comparison group is impossible, and the analysis cannot proceed. In some instances, individuals with propensity scores

lying outside of the region of common support are dropped from subsequent analyses. Propensity scores satisfy the balancing condition if, conditional on the estimated score, the distribution of the variables included in the propensity model is the same in the treated and control groups.

6.2.2.2 Implementing propensity score matching

The first step in a propensity matching analysis is to estimate the propensity score; the second step is to then use that estimated score to estimate the treatment effects of interest. There are several ways that the propensity score can be used to achieve this, and following is a presentation of two common approaches: (i) matching and (ii) inverse probability of treatment weights (IPTW). Matching uses the propensity score to create a statistically equivalent control group that can be compared to the treatment group. Treated individuals are matched to one or more untreated individuals with the same, or similar, propensity scores. If each treated case is matched to a single untreated case this is referred to as *one-to-one* matching, otherwise the matching is *one-to-many*. The distance between scores that constitutes a valid match is specified by the analyst, and referred to as a *caliper*; if the caliper is set to zero then matched individuals must have exactly the same propensity score. Individuals with propensity scores that are not on the common support region are often dropped at this stage in the analysis because their propensity scores are too extreme to offer a suitable match.

The matching process can be performed with or without replacement – *with replacement* returns matched individuals back into the pool of potential matches, which means that control individuals can be matched to more than one treated individual; *without replacement* restricts this process so that matched individuals are not replaced, and can only be matched to one treated case. Once the matching is carried out, outcomes for treated cases can be compared to the retrospectively constructed control group.

An alternative to matching is to apply inverse probability of treatment weights (IPTW).[70] This approach uses the estimated propensity scores to derive a set of statistical weights that are then used in an analysis of the outcomes of interest to estimate the treatment effect. The weights correct for underlying differences between treated and untreated groups by appropriately varying the weight, or contribution, of control individuals to the analysis. For example, individuals who had a low estimated probability of receiving the treatment, and ultimately did not receive the treatment, will receive a low statistical weight, and therefore, their outcomes will contribute less to the analysis. On the other hand, individuals with a high estimated probability of receiving the treatment, who *were not treated* will receive a high statistical weight, and thus contribute more to the analysis. The implication is that the best comparisons can be made with individuals who seemed likely to receive the treatment but did not.

Statistical weights can be calculated in different ways to estimate different quantities of interest, notably the average treatment effect (ATE), or the average treatment effect on the treated (ATT).[69] While the ATE estimates the average effect of applying the treatment to the entire population, the ATT estimates the effect of the treatment on *those who actually received the treatment*. These quantities are both valid, but may be more or less of interest depending on context. For example, if a treatment is very expensive and/or invasive, it is likely to be administered to targeted subgroups rather than whole populations, and therefore the ATT is of more interest. The ATE is more applicable in estimating the effect of broad-based interventions that are rolled out to whole populations, such as immunisation programs or advertising campaigns.

6.2.3 Propensity score matching in the context of Brighter Futures

This section highlights a series of questions that are pertinent to the application of propensity score matching to assess the impact of the Brighter Futures program using the Seeding Success data resource. Rather than provide definitive answers to the questions raised here, the different options that are available are presented, and the relative advantages and disadvantages of these options are summarised. Where applicable, the ways that the alternative options can answer different research questions of interest are discussed.

6.2.3.1 The definition of "treatment"

The available program data offer alternative ways to conceptualise the Brighter Futures program as a "treatment". We can distinguish between families who were engaged by Brighter Futures, but did not progress to participation, and those families who did participate in the program. For the majority of families, the duration of Brighter Futures participation can be calculated, so it is also possible to distinguish between families who were exposed to the program for a longer or shorter duration. However, we cannot distinguish between the precise treatments or combinations or treatments received; neither can we quantify the dosage in terms of intensity of treatment provided/received, for example the frequency of interactions, or the total hours interacting with the service.

Depending on how Brighter Futures is conceptualised as a treatment, we can answer different questions about the effectiveness of the program. For example, if we consider any family approached by Brighter Future as "treated", regardless of whether or not they ultimately participate, we can evaluate the program on an *intention to treat* basis. The intention to treat estimate tells us the average effect of the program, accounting for the fact that not everyone who is offered the program will ultimately participate. We may instead be more interested in the effect of the program on those who actually received it, in which case treatment could be defined as participation only. Incorporating information about the duration of participation could also be used to refine the definition of treatment. For example, treatment could be defined by a minimum period of participation in the program, such as six months. Alternatively, all those initiating the program could be considered treated, regardless of the duration of their involvement, in which case the evaluation would be on an intention to treat basis, conditional on participation.

6.2.3.2 Selection of variables for the propensity model

Once treatment is defined, we must consider which baseline variables will be included in the model used to estimate the propensity of receiving the treatment. In order to minimise bias on the treatment effect estimates, the most useful variables to include are those that predict both the treatment status and the outcome being evaluated.[71,72] [73]Variables that are unrelated to treatment status but are related to the outcome will have no impact on bias reduction, but can increase the precision of estimated effects, and therefore should also be included. Variables that are related to the treatment status but entirely unrelated to the outcome of interest will improve the fit of the propensity model, but their inclusion will increase the variance of estimates while having no impact on bias reduction. Such variables should, therefore, be considered carefully before including them in the model.

Variables shouldn't be included in the propensity model if they are potentially caused by the treatment. For example, although developmental vulnerability on the physical and wellbeing domain may be associated with both the propensity to receive the Brighter Futures treatment, and

hospitalisations for injury, it would not be included in a propensity model because this variable is potentially impacted by the treatment.

Many covariates available in the Seeding Success data resource plausibly satisfy the key property of being associated with both treatment status and outcomes of interest. These include child level covariates (e.g. sex, English second language status, birth characteristics), family-level covariates (e.g. parental occupation and education), and area-level covariates (e.g. geographical remoteness, area-level disadvantage). The child protection notifications from the KIDS dataset offer one of the most promising sources of data to identify a comparable control group to the Brighter Futures children given notification to the child protection system is a key pathway for vulnerable families into Brighter Futures. In this study, the available subset of child protection notifications provided to the researchers were those classified as at risk of significant harm (ROSH).

It should be noted that although many of the available variables pertain to the child, the unit for Brighter Futures program participation is the family. This means that a child's participation in the program may have been prompted by incidents involving other family members, such as a sibling; however, notifications relating to other family members are not available in the study data. Further, data on interactions with other concurrent early intervention programmes is unavailable. These caveats will weaken the power of the propensity score models to predict program participation because not all explanatory factors are available.

6.2.3.3 Selection of the pool of untreated children

The propensity model must be fitted to data from a population that includes both treated and untreated individuals. The population of untreated children can be restricted in various ways. Three possible options are outlined below:

i. All cohort children who did not receive the treatment.
ii. All cohort children who were known to child protection services during the study period, but did not receive the treatment.
iii. All cohort children who were engaged by Brighter Futures but did not participate.

Option (i) is the least restrictive, maximising the number of potential comparison children. However, this choice will include a large number of children whose family have no interactions with child protection services, and are unlikely to have been considered eligible for the program. As such, these children and their families have a zero probability of receiving the treatment. Option (ii) restricts the pool of untreated children to the 15% of the cohort who were known to FACS during the study period. In this way, the children and their families have at least some possibility of being considered suitable to participate in Brighter Futures, and thus have a non-zero probability of receiving the treatment. Option (iii) is the most restrictive, and is contingent on the definition of treatment referring to participation rather than considering both program engagement and/or participation as treatment. The appeal of option (iii) is that the families who were engaged by Brighter Futures but did not participate are quite likely the families in the cohort who are most comparable to those who did participate. However, the families who were engaged but did not participate in the program are also likely to differ on key measured and unmeasured characteristics that are related to the decision that they were not suitable, or were not willing, to participate in the program.

6.2.3.4 A methodological challenge: heterogeneous age at the start of treatment

The Brighter Futures program was open to families with children less than nine years of age; for the set of cases that we can practically examine using the Seeding Success data resource, the age at first engagement and/or participation ranged from 0 – 5. This heterogeneity in the timing of the start of treatment has implications for the propensity modelling strategy. The age at the start of treatment is highly relevant to the analysis of injury outcomes because, as seen in the main body of the report, rates of emergency department visits and/or hospital admissions for injury vary by age in the general population of children during early childhood. Moreover, the type of treatment offered and received is likely to be different for families with children at different ages, although this information is unavailable in the source data. The timing of treatment is also relevant to the distribution of other covariates that we may want to include in the propensity model. For example, it is appealing to include ROSH reports in the propensity matching models. However, the ROSH reports are longitudinal in nature and there may be multiple records per individual accrued over time. In order to include the ROSH reporting histories in the propensity score model, new variables must be derived that aggregate these time-series data so that there is a single observation per individual. Derived variables also need to: (i) exclude information arising after treatment begins, which may be an effect of the treatment; and (ii) take into account varying at-risk periods, for example, the fact that children who were aged one when their families joined Brighter Futures have less time to accrue ROSH reports compared with children who were four when their family joined the program. Simple aggregate variables do not necessarily satisfy these conditions. For example: aggregating the time-series data to derive a variable such as "*The number of child protection reports ever received"* will include information arising after treatment; an alternative construct "*The number of child protection reports received in the 12 months before treatment*" will be undefined for untreated children.

A simple way to overcome the issues related to the heterogeneity in age at the start of Brighter Futures participation is to stratify the treated sample by age. Under this approach, the treated sample would be separated into *n* categories, and the evaluation repeated *n* times, on groups of children who enrolled in Brighter Futures at similar ages. Having stratified the sample by age, it becomes easier to include time-varying data on ROSH reports, by deriving variables such as "*The number of child protection reports received at age one".* This variable aggregates longitudinal information to a time-invariant variable, and is defined for treated and untreated children. Of course, this could only be included in analyses that aim to estimate the effect of participating in Brighter Futures for children who enrolled after the age of one; this variable could not be used to estimate the effect of the program on children who started participation before their first birthday. A negative consequence of stratification by age at treatment is that the size of the treated group is diminished, which increases the variance of estimated treated effects.

6.2.4 Methods for the propensity score matching analysis

A scoping analysis was performed to assess the plausibility of using propensity score matching to assess the impact of Brighter Futures on early childhood outcomes, using the Seeding Success data resource. This section describes the methods employed, with reference to the questions raised in the previous section.

6.2.4.1 Data

The Seeding Success study population includes data on 166,278 children born in NSW with an AEDC record in 2009 or 2012. For this scoping analysis, we proceeded with option (ii) when it came to

restrict the pool of untreated children in the analysis, as described in Section 6.2.3.3. This involved restricting the study population to the 27,412 (16%) children who also had one or more records in the linked data extracted from the Key Information and Directory System (KiDS), including ROSH reports, OOHC records and Brighter Futures program records[2].

6.2.4.2 Treatment

Children were considered "treated" if their families had any record of Brighter Futures participation between the time the study child was born and the end of their first year of school. Children of families who were engaged, but did not participate, were considered untreated. We did not account for early drop-out or disengagement from the program—children of families who initiated the program were considered treated, even if they stopped interacting shortly after starting. Therefore the analysis is on an intention-to-treat basis, conditional on participation.

6.2.4.3 Outcome

Although the main body of this report focuses on emergency department visits and/or hospitalisation for injury during early childhood, a different outcome was used for the purpose of this scoping analysis: early childhood development, the primary outcome for the Seeding Success study. The advantage of focusing on child development rather than injury is that child development data were collected for all cohort children during a brief window in their first year of schooling, whereas hospitalisations for injury could occur at any time, and repeatedly, throughout childhood. It is more straightforward to analyse a single time-point outcome (e.g. child development) compared to a repeated measure outcome (e.g. injuries), allowing the scoping analysis to focus on the effects of propensity score matching rather than the complications of the analytical model.

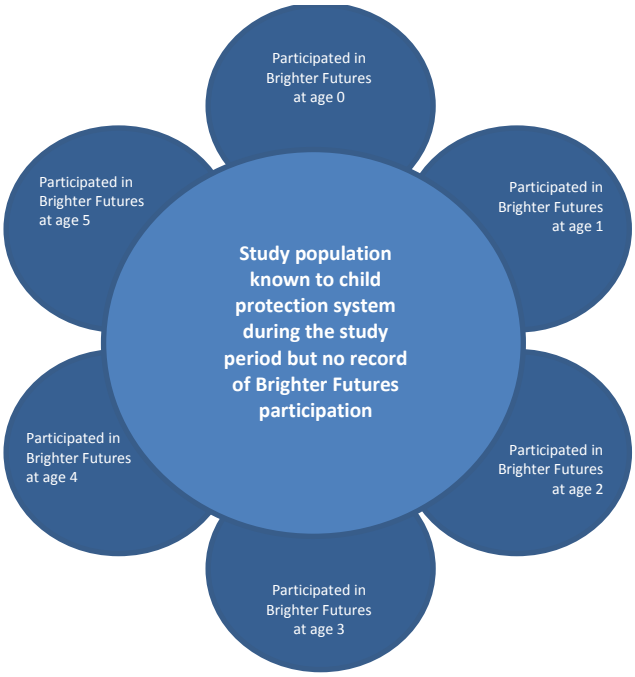
An assessment of early childhood development is available for all children in Seeding Success study population, ascertained from their linked Australian Early Development Census (AEDC) data. This triennial census centres on a teacher-based assessment of development, collected during children's first year of school, measuring development on five domains: physical health, social competence, emotional maturity, language and cognitive skills and communication and general knowledge. Children with scores in the bottom decile on a domain, as per the 2009 AEDC cut-point, are classified as vulnerable on that domain. We examined these five binary indicators of vulnerability, as well as a sixth composite measure, which classified children as vulnerable if they were vulnerable on one or more of the individual domains

6.2.4.4 Stratification by age at participation

As discussed in the previous section, in order to include variables based on the time-varying ROSH report data, it is necessary to stratify the treated sample by age at Brighter Futures participation. One year age bands were chosen, and the treated sample was stratified into six groups: children of families who participated in Brighter Futures at age i, for $i = 0 \ldots 5$ (Figure 16). In each case, the source of potential comparison cases comprised all children in the Seeding Success study population who were known to child protection services during the study period, but did not participate in Brighter Futures. The analysis of children enrolled at age i excluded children who participated in Brighter Futures at age $j \neq i$ (Figure 17).

[2] This figure exceeds the number of children with a child protection record in Figure 1 (N=12,710) because we did not restrict the sample to children with an AEDC in 2012 for the propensity score matching analysis.

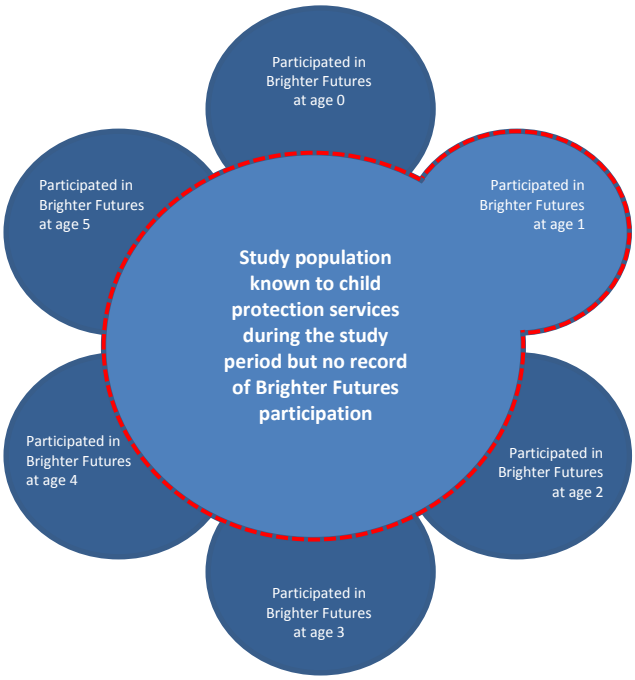
Figure 16: Stratification of the treated cases by age at participation in Brighter Futures.



Children whose families participated in Brighter Futures were stratified by age and analysed separately. In each analysis the pool of untreated children was the same—all children in the study population who were known to the child protection system but did not participate in Brighter Futures (centre circle

).

Figure 17: Identifying treated and untreated cases for the analysis of children participating in the program at age 1.



The dashed red line indicates the pool of children used to assess the impact of Brighter Futures participation at age 1. Note that the analysis excludes children who participated in Brighter Futures at younger or older ages.

6.2.4.5 Selection of variables for the propensity model

A list of variables that were readily available in the Seeding Success data resource, and potentially useful for the propensity score matching, was compiled. Table 10 compares the distribution of these variables for “Treated” (children of families who participated in Brighter Futures at any age during the study period) and “Untreated” (children who never participated in Brighter Futures but had some other known contact with child protection services) groups.

Child factors associated with Brighter Futures participation included being male, Aboriginal, a firstborn child and speaking English as a first language. Maternal factors associated with participation included being a teenage mother, Australian born, single, not admitted as a private patient or with private health insurance at the child’s birth, and having smoked during pregnancy. Family factors associated with participation included not being in paid work and having a low-skilled occupation. Area-level factors associated with participation included living in a more geographically remote or outer regional location in NSW and living in a relatively disadvantaged area.

The two available family-level measures of socio-economic disadvantage—parental occupation and education—were associated with exposure status. However, more than one third of the sample has missing data for these variables: 23% because the children did not attend a NSW Public School or attended school outside of NSW; 12% because the NSW Public School enrolment record has missing data on some or all variables. As such, a complete case analysis incorporating these family-level measures of advantage/disadvantage would discard a sizable proportion of the data. Given the relatively small numbers of treated cases in this population, discarding incomplete cases is highly undesirable. As an alternative, indicator variables were derived to identify two subgroups, namely children who attended a non-government school, and children who attended a government school but did not have a complete enrolment. Exploratory analysis indicated that both of these variables were associated the treatment and outcome.

Table 10: Potential propensity matching variables by treatment status.

		Untreated		Treated		Total		Chi Sq (p)
Variable	Subgroup	N	%	N	%	N	%	
Population		23782	100	3630	100	27412	100	
Sex								
	Male	12464	52.4	1948	53.7	14412	52.6	1.98 (0.159)
	Female	11318	47.6	1682	46.3	13000	47.4	
Aboriginal Status								
	Non-Aboriginal	19548	82.2	2713	74.7	22261	81.2	114.8 (0.000)
	Aboriginal	4234	17.8	917	25.3	5151	18.8	
Number of previous pregnancies								
	0	8223	35	1359	38	9582	35.4	18.27 (0.000)
	1	6767	28.8	1038	29.1	7805	28.9	
	2+	8401	35.8	1168	32.7	9569	35.4	
	Missing	87	0.4	8	0.2	95	0.4	
Maternal age								
	<20	2746	11.5	562	15.5	3308	12.1	134.7 (0.000)
	20-24	5947	25	1089	30	7036	25.7	
	25-29	6125	25.8	912	25.1	7037	25.7	
	30-34	5362	22.5	676	18.6	6038	22	
	35+	3600	15.1	391	10.8	3991	14.6	
Mother's country of birth								
	Overseas	4659	19.6	567	15.6	5226	19.1	32.79 (0.000)
	Australia	18980	79.8	3044	83.9	22024	80.3	
	Missing	143	0.6	19	0.5	162	0.6	
Mother's partnership status								
	Other	9154	40.2	1550	45.4	10704	40.9	33.53 (0.000)
	Married/de facto	13330	58.6	1829	53.6	15159	58	
	Missing	263	1.2	32	0.9	295	1.1	
Private patient or private insurance (child or mother at child's birth)								
	No	20299	85.4	3294	90.7	23593	86.1	82.70 (0.000)
	Yes	3180	13.4	290	8	3470	12.7	
	Missing	303	1.3	46	1.3	349	1.3	
Parental education								
	≥ Year 9 (Either parent)	14100	59.3	2185	60.2	16285	59.4	73.56 (0.000)
	≤ Year 9 (Both parents)	1490	6.3	322	8.9	1812	6.6	
	Not Applicable	5606	23.6	674	18.6	6280	22.9	
	Missing	2586	10.9	449	12.4	3035	11.1	
Highest ranking occupation, either parent								
	1. Managers/professionals	1625	6.8	140	3.9	1765	6.4	294.3 (0.000)
	2. Business /assoc profs	2108	8.9	236	6.5	2344	8.6	
	3. Trades/clerks/services	3609	15.2	455	12.5	4064	14.8	
	4. Drivers/hospitality/labour	3892	16.4	630	17.4	4522	16.5	
	5. Not in paid works	3905	16.4	947	26.1	4852	17.7	
	N/A - No NSW PSE data	5606	23.6	674	18.6	6280	22.9	
	Missing	3037	12.8	548	15.1	3585	13.1	
Smoking during pregnancy								
	No smoking	14456	61.6	2043	57.2	16499	61	25.16 (0.000)
	Smoked	8888	37.9	1507	42.2	10395	38.4	
	Missing	134	0.6	23	0.6	157	0.6	
Received antenatal care in first 20 weeks of pregnancy								
	No	4416	18.8	669	18.7	5085	18.8	0.37 (0.829)
	Yes	18546	79	2831	79.2	21377	79	
	Missing	516	2.2	73	2	589	2.2	
Small for gestational age								
	No	19810	84.4	2991	83.7	22801	84.3	1.64 (0.440)
	Yes	3646	15.5	580	16.2	4226	15.6	
	Missing	22	0.1	2	0.1	24	0.1	
Resuscitation of baby at birth								
	No	13784	58.7	2071	58	15855	58.6	0.74 (0.689)
	Yes	9659	41.1	1497	41.9	11156	41.2	
	Missing	35	0.1	5	0.1	40	0.1	
Maternal comorbidity during pregnancy (pre-existing or gestational diabetes and/or hypertension)								

Variable	Subgroup	Untreated N	Untreated %	Treated N	Treated %	Total N	Total %	Chi Sq (p)
	No/Not stated	21131	90	3225	90.3	24356	90	0.23 (0.633)
	Yes	2347	10	348	9.7	2695	10	
5 min APGAR score < 7								
	No	23016	98	3501	98	26517	98	0.13 (0.935)
	Yes	345	1.5	55	1.5	400	1.5	
	Missing	117	0.5	17	0.5	134	0.5	
Admitted to Neonatal ICU or Special care nursery								
	No	18640	79.4	2860	80	21500	79.5	0.82 (0.663)
	Yes	4809	20.5	709	19.8	5518	20.4	
	Missing	29	0.1	4	0.1	33	0.1	
English as a second language at school entry								
	No	20688	87	3236	89.1	23924	87.3	13.2 (0.000)
	Yes	3094	13	394	10.9	3488	12.7	
Accessibility/Remoteness Index of Australia (ARIA)								
	Major City	13301	56.9	1682	47.2	14983	55.6	147.0 (0.000)
	Inner Regional	6944	29.7	1228	34.4	8172	30.3	
	Outer Regional	2771	11.8	544	15.3	3315	12.3	
	Remote/Very Remote	373	1.6	113	3.2	486	1.8	
Area-level disadvantage								
	1 (most disadvantaged)	3332	14.2	581	16.3	3913	14.5	57.50 (0.000)
	2	3291	14.1	613	17.2	3904	14.5	
	3	9805	41.9	1493	41.9	11298	41.9	
	4	4128	17.6	531	14.9	4659	17.3	
	5 (least disadvantaged)	2833	12.1	349	9.8	3182	11.8	
AEDC collection cycle								
	1 (2009)	12681	53.3	1382	38.1	14063	51.3	293.1 (0.000)

Factors related to the child's perinatal health, including weight for gestational age and admission to neonatal intensive care, were not associated with treatment status so these were excluded from the propensity score models. The final set of predictive variables are summarised in Table 11.

Table 11: Variates included in the propensity score models.

Child variables	**Maternal variables**	**Family-level indicators of advantage/disadvantage**	**Area-level variables**
Aboriginal status English second language (ESL) status Number of ROSH reports at age X Number of ROSH reports at age X-1 Number of substantiated ROSH reports at age X Number of substantiated ROSH reports at age X-1	Number of previous pregnancies Age at child's birth Country of birth Partnership status Smoking during pregnancy	Private insurance/patient status Child attended a non-government school Public school enrolment form was incomplete	Accessibility/Remoteness Index of Australia (ARIA) Index of Relative Socio-economic Advantage and Disadvantage (IRSAD)

6.2.4.6 Fitting the propensity score models

A separate propensity score model was estimated for each of the six age strata, that is, children who were enrolled in Brighter Futures at ages i, for $i = 0 \ldots 5$. For each model, the dichotomous outcome variable was Brighter Futures participation at age i (1) versus no participation (0). Children who participated in Brighter Futures at age $j \neq i$ were excluded from the model for enrolment at age i. The models were estimated using logistic regression, with each variable listed in Table A2 included as a main effect predictor. From each model, the corresponding propensity score—the estimated probability of participating in Brighter Futures at age i—was calculated directly from the fitted model parameters.

6.2.4.7 Assessing the propensity scores

We performed two tests to assess the validity of the estimated propensity scores. To confirm that the scores satisfied the condition of common support, we examined plots of the estimated probabilities for treated and untreated children. To test that the estimated scores satisfied the balancing condition, we compared the Z-statistic from a logistic regression model of each individual variable on the treatment outcome from two models, one that conditioned on the propensity score, and one that did not.

6.2.4.8 Estimating treatment effects

The estimated propensity scores were used in two different ways to estimate the effect of Brighter Futures on early childhood development:

i. 1:2 Matching (with callipers)
   Each treated child was matched to two untreated children with a similar propensity score, within a caliper of 0.01. The matching algorithm allowed replacement, i.e. the same control child could be matched to multiple treated children.

ii. Inverse Probability of Treatment Weights (IPTW)

   The treatment weight was calculated as

$$w = \begin{cases} 1 & where\ treatment = 1 \\ p/(1-p) & where\ treatment = 0 \end{cases}$$

   where p indicates the estimated propensity score.

   This formulation of the IPTW estimates the Average Treatment Effect on the Treated (ATT), i.e. the effect of the program for people who actually received the program. This estimate is of primary interest in the context of Brighter Futures, which is targeted at a small subpopulation, rather than something that is broadly available to the whole population.

For each application of the propensity scores, six binary outcomes were examined using logistic regression, and four estimates were compared for each outcome. The outcomes included developmental vulnerability on the physical and wellbeing, social competence, emotional maturity, language/cognition, and communication/general knowledge domains, as well as the composite outcome of vulnerable on one or more domains. The estimates were:

i. Raw – the raw estimate, not accounting for any confounding of the treatment

ii. Raw + controls – the covariates used in the propensity score models were included in the logistic model as controls
iii. IPTW/PSM – the estimate utilising the propensity score (alternatively the IPTW estimate and the 1:2 matching estimate)
iv. IPTW/PSM + controls – the estimate utilising the propensity score (alternatively the IPTW estimate and the 1:2 matching estimate), as well as including the variables from the propensity models as control variables

All estimates were presented as odds ratios, with 95% confidence intervals.

6.2.5 Results of the propensity score matching analysis

6.2.5.1 Propensity models

Table 12 presents the estimated parameters (odds ratios and p values) from the six propensity score models. For most predictive variables, the estimated effect on the log-odds of participation varied depending on the age stratum in question. For some variables, the variation was only in terms of significance of the parameter estimate. For example, Aboriginal children had higher odds of participation at all ages, but the estimated effect was only significant from age 2. This variation is likely due, in part, to the small numbers of children receiving the treatment for each age group. For other variables, the estimate varied both in significance and direction. For example, girls were significantly more likely to be managed at age zero, but at ages 3 and 4, girls were significantly less likely to participate. Children who received a ROSH report in the year the family participated in the Brighter Futures program had significantly higher odds of Brighter Futures participation in that year. In contrast, children with substantiated ROSH reports were less likely to participate in the program.

Table 12: Estimated odds ratios (and p-values) from 6 logistic regression models for the probability of Brighter Futures program participation at age i, for i=0…5.

		Age at start of Brighter Futures participation					
Variable	**Category**	**Age 0**	**Age 1**	**Age 2**	**Age 3**	**Age 4**	**Age 5**
Sex	Male	1.000	1.000	1.000	1.000	1.000	1.000
		(.)	(.)	(.)	(.)	(.)	(.)
	Female	1.483	1.108	0.979	0.774	0.783	0.942
		(0.00)	(0.34)	(0.83)	(0.01)	(0.00)	(0.51)
Aboriginality	Non-Aboriginal	1.000	1.000	1.000	1.000	1.000	1.000
		(.)	(.)	(.)	(.)	(.)	(.)
	Aboriginal	1.212	1.240	1.271	1.341	1.363	1.570
		(0.27)	(0.12)	(0.05)	(0.01)	(0.00)	(0.00)
Number of previous pregnancies	0	1.000	1.000	1.000	1.000	1.000	1.000
		(.)	(.)	(.)	(.)	(.)	(.)
	1	1.424	1.337	0.992	0.835	0.940	0.929
		(0.03)	(0.04)	(0.95)	(0.12)	(0.56)	(0.52)
	2+	1.047	1.186	0.897	0.726	0.805	0.658
		(0.81)	(0.28)	(0.42)	(0.01)	(0.06)	(0.00)
Maternal age (years)	<20	1.000	1.000	1.000	1.000	1.000	1.000
		(.)	(.)	(.)	(.)	(.)	(.)
	20-24	0.601	0.711	0.942	1.180	1.106	1.041
		(0.02)	(0.05)	(0.70)	(0.28)	(0.47)	(0.79)
	25-29	0.543	0.559	0.863	0.932	1.013	1.087

Variable	Category	Age at start of Brighter Futures participation					
		Age 0	Age 1	Age 2	Age 3	Age 4	Age 5
		(0.01)	(0.00)	(0.39)	(0.68)	(0.93)	(0.61)
	30-34	0.582	0.500	0.656	1.055	0.936	0.826
		(0.03)	(0.00)	(0.03)	(0.77)	(0.69)	(0.30)
	35+	0.445	0.609	0.763	0.990	0.720	0.969
		(0.00)	(0.03)	(0.20)	(0.96)	(0.09)	(0.88)
Maternal country of birth	Overseas	1.000	1.000	1.000	1.000	1.000	1.000
		(.)	(.)	(.)	(.)	(.)	(.)
	Australia	0.702	0.898	0.900	1.241	1.034	1.400
		(0.07)	(0.55)	(0.50)	(0.17)	(0.81)	(0.04)
Partnership status	No partner	1.000	1.000	1.000	1.000	1.000	1.000
		(.)	(.)	(.)	(.)	(.)	(.)
	Partner	1.033	0.815	1.006	0.963	0.976	0.963
		(0.82)	(0.08)	(0.96)	(0.70)	(0.79)	(0.71)
Private patient/health insurance status	Not private	1.000	1.000	1.000	1.000	1.000	1.000
		(.)	(.)	(.)	(.)	(.)	(.)
	Private	0.681	0.724	0.721	0.674	0.693	0.576
		(0.11)	(0.14)	(0.08)	(0.02)	(0.02)	(0.00)
Smoking during pregnancy?	No	1.000	1.000	1.000	1.000	1.000	1.000
		(.)	(.)	(.)	(.)	(.)	(.)
	Yes	0.845	0.965	0.912	1.019	1.046	0.856
		(0.26)	(0.77)	(0.39)	(0.85)	(0.62)	(0.13)
English as a second language	No	1.000	1.000	1.000	1.000	1.000	1.000
		(.)	(.)	(.)	(.)	(.)	(.)
	Yes	1.432	1.154	0.933	1.131	0.986	1.090
		(0.10)	(0.48)	(0.70)	(0.49)	(0.93)	(0.63)
Attended non-government school	No	1.000	1.000	1.000	1.000	1.000	1.000
		(.)	(.)	(.)	(.)	(.)	(.)
	Yes	0.860	0.845	0.784	0.879	0.678	0.672
		(0.35)	(0.22)	(0.05)	(0.26)	(0.00)	(0.00)
Completed an enrolment form	Yes	1.000	1.000	1.000	1.000	1.000	1.000
		(.)	(.)	(.)	(.)	(.)	(.)
	No	1.076	0.851	1.081	1.028	0.889	0.728
		(0.71)	(0.36)	(0.59)	(0.85)	(0.38)	(0.05)
Area-level remoteness	Major city	1.000	1.000	1.000	1.000	1.000	1.000
		(.)	(.)	(.)	(.)	(.)	(.)
	Inner regional	1.859	1.277	1.185	1.356	1.277	1.216
		(0.00)	(0.07)	(0.15)	(0.01)	(0.01)	(0.07)
	Outer regional	1.510	1.889	1.075	1.464	1.281	0.990
		(0.12)	(0.00)	(0.67)	(0.02)	(0.10)	(0.96)
	Remote	4.281	1.352	1.412	2.954	1.609	1.057
		(0.00)	(0.47)	(0.27)	(0.00)	(0.10)	(0.88)
Area-level disadvantage	1 (Most Disadvantaged)	1.000	1.000	1.000	1.000	1.000	1.000
		(.)	(.)	(.)	(.)	(.)	(.)
	2	1.243	1.082	1.001	1.165	1.066	1.379
		(0.37)	(0.67)	(1.00)	(0.34)	(0.66)	(0.06)
	3	1.050	1.011	0.742	1.078	0.952	1.173

		Age at start of Brighter Futures participation					
Variable	**Category**	**Age 0**	**Age 1**	**Age 2**	**Age 3**	**Age 4**	**Age 5**
		(0.83)	(0.95)	(0.04)	(0.63)	(0.71)	(0.31)
	4	1.526	0.954	0.603	1.080	0.830	1.202
		(0.10)	(0.83)	(0.01)	(0.68)	(0.26)	(0.31)
	5 (Least Disadvantaged)	2.310	1.510	0.683	1.482	0.993	0.933
		(0.00)	(0.08)	(0.08)	(0.05)	(0.97)	(0.76)
ROSH* report	Age 0	1.955	1.373				
		(0.00)	(0.00)				
	Age 1		1.202	0.953			
			(0.00)	(0.30)			
	Age 2			1.270	0.941		
				(0.00)	(0.22)		
	Age 3				1.198	0.943	
					(0.00)	(0.17)	
	Age 4					1.212	0.968
						(0.00)	(0.50)
	Age 5						1.235
							(0.00)
Substantiated ROSH* report	Age 0	0.468	0.461				
		(0.00)	(0.05)				
	Age 1		0.784	0.977			
			(0.00)	(0.79)			
	Age 2			0.659	0.885		
				(0.00)	(0.28)		
	Age 3				0.703	0.752	
					(0.00)	(0.02)	
	Age 4					0.861	0.773
						(0.02)	(0.07)
	Age 5						0.765
							(0.01)
Intercept		0.006	0.016	0.033	0.023	0.040	0.019
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

* ROSH = Risk of Significant Harm

6.2.5.2 Balance diagnostics

Figure 18 presents the distribution of the estimated six propensity scores of treatment (Brighter Futures participation) at age 0 – 5 for those who were treated and those who were untreated. It is clear from the figures that there is a large overlap between the estimated distributions for both groups, which is known as the common support region.

Figure 19 presents Z statistics from a series of logistic regression models, each including a single predictor, and modelling the odds of engagement at age 0 (left panel) and engagement at age 4 (right panel). Note that the outcome of enrolment at age 0 and 4 are presented as examples here, but the results were similar for enrolment at all ages between 0 and 5 years. The models were estimated with and without weights based on the estimated propensity scores. Variables with unweighted estimates falling outside of the dashed lines at +/- 1.96 were significantly associated

with treatment status. The weighted estimates cluster around the zero line, indicating no association with treatment status and signifying that the estimated propensity scores have balanced the sample in terms of the variables included in the propensity model.

Figure 18: Assessing the region of common support: Estimated propensity of treatment at ages 0 – 5, for treated and untreated children.

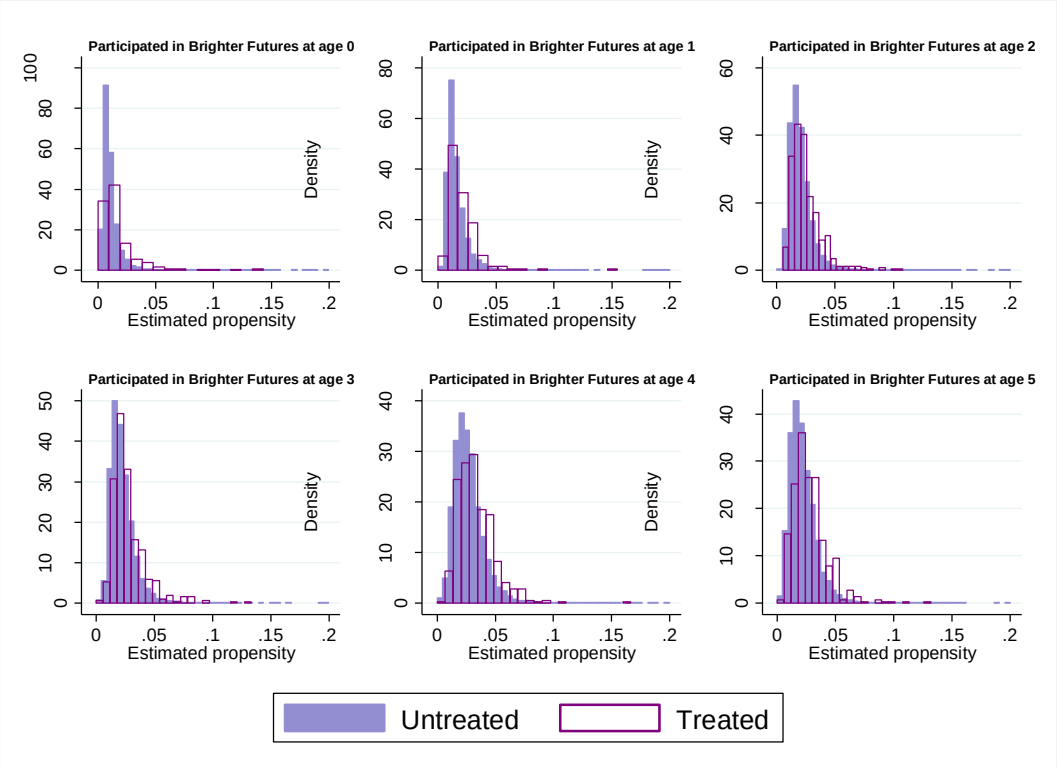
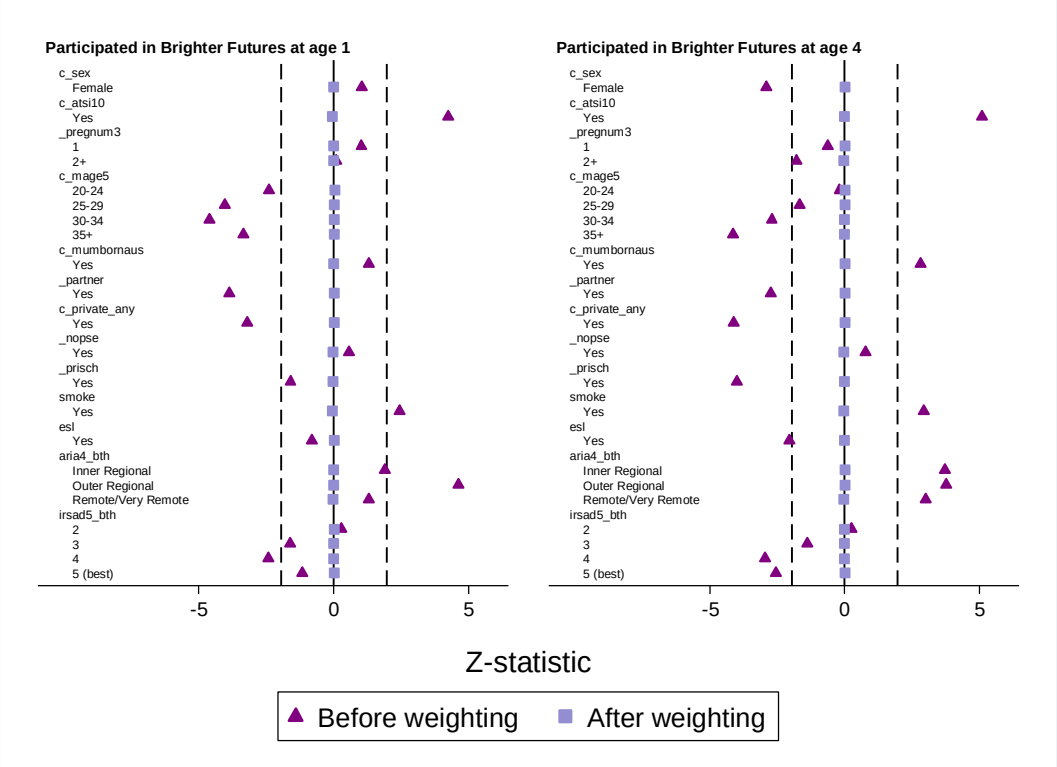


Figure 19: Estimated Z statistics based on weighted and unweighted logistic models of receiving the treatment at age 0 (left) and age 4 (right).

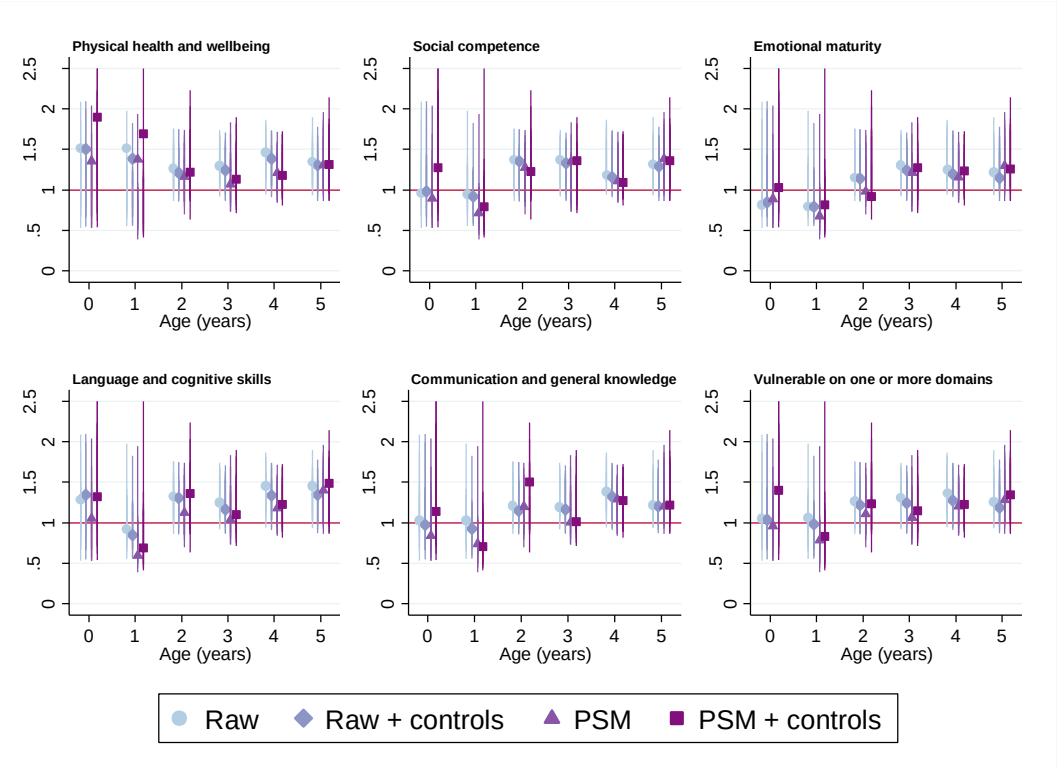


In Figure 20 and Figure 21, treatment effects, presented as odds ratios with 95% confidence intervals, were estimated for each of the five early development domains, and the composite indicator of vulnerability on one or more domains. For purposes of comparison, estimates based on the propensity score matching methods are presented alongside two more immediate approaches: (i) raw estimates which use no covariate information, and (ii) estimates which included the covariate information as statistical controls. The results based on 1:2 matching are presented in Figure 20 and the results based on IPTW are presented in Figure 21.

Although there was variability in the estimated odds ratios across the age strata and outcomes examined, the majority of estimates were between 1 and 1.5, which translates to the odds of developmental vulnerability being up to 50% higher for children whose families participated in Brighter Futures compared with the untreated comparison group. However, the point estimates were variable, and the confidence intervals were wide (reflecting small sample size) and intersected one, meaning that the estimated treatment effects were not statistically significant. This was especially true for the analysis of children participating at age 0—the smallest treatment group—and for the propensity score estimates that included the covariate information. The variance of the estimates is partly driven by the small subgroup sizes that result from stratifying by age of participation.

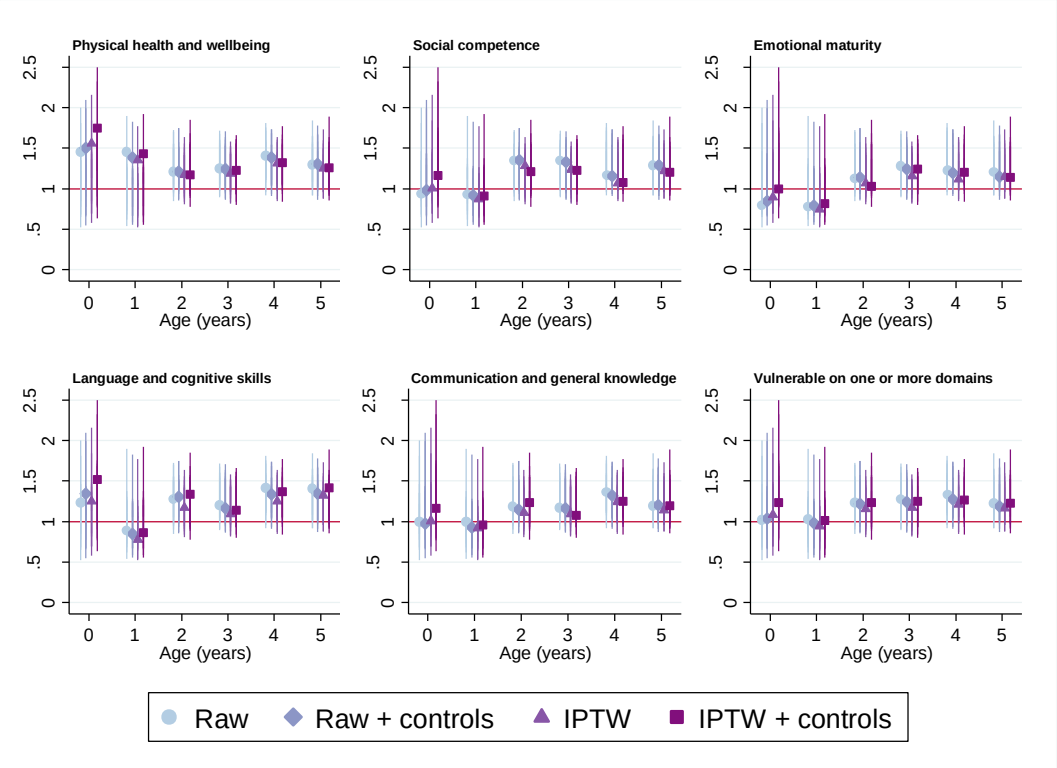
For many outcomes, the estimate incorporating the propensity scores were shifted in the expected direction—i.e. towards there being a positive treatment effect of Brighter Futures on developmental vulnerability—however, the magnitude of the shifts were small, especially given the scale of uncertainty around the estimates.

Figure 20: Estimated effect (OR and 95% CI) of Brighter Futures participation using the 1:2 matching application of propensity scores.



Raw: The raw estimate, not accounting for any confounding of the treatment
Raw + controls: The covariates used in the propensity score models were included in the logistic model as controls
PSM: The estimate utilising the propensity score via 1:2 matching
PSM + controls: The estimate utilising the propensity score via 1:2 matching, including the variables from the propensity models as control variables

Figure 21: Estimated effect (OR and 95% CI) of Brighter Futures participation using the IPTW application of propensity scores.



Raw: The raw estimate, not accounting for any confounding of the treatment
Raw + controls: The covariates used in the propensity score models were included in the logistic model as controls
IPTW: The estimate utilising the propensity score via inverse probability of treatment weights
PSM + controls: The estimate utilising the propensity score via inverse probability of treatment weights, including the variables from the propensity models as control variables

6.2.6 Discussion

In this study, we assessed the feasibility of applying quasi-experimental methodologies to the Seeding Success data resource to estimate the impact of the Brighter Futures program on child outcomes available in the source data. The summary of the findings highlights some important considerations and challenges in the application of propensity score matching to identify a comparison group of children with similar characteristics to the children whose families participated in Brighter Futures between birth and school age. Although the application of propensity score matching methods identified comparison groups that were similar to the Brighter Futures children based on measured characteristics available in the data resource, the estimates of the program effect on child development outcomes did not differ substantively from results based on a crude comparison of treated and all untreated children in the general population. This suggests that there may be barriers to applying this quasi-experimental approach, and isolating the effect of the treatment, in this context.

After applying propensity score matching methods to identify a suitable comparison group to the Brighter Futures children, we found no significant association between Brighter Futures participation and developmental vulnerability on any domain in the first year of school, which may, at least in part, be attributed to small sample sizes and wide confidence intervals around the point estimates. Although child development is not a direct target of the program, it is plausible that the program may impact positively on child development for families who participate because a number of the program goals are likely to improve family functioning, the home environment and parenting skills. On the other hand, child development may be considered a distal outcome in relation to the immediate goals of the program that are oriented towards enabling the child to live safely at home with their family. It is likely that the methods used to estimate the treatment effect were unable to correct for the non-random allocation of children to the program, particularly in relation to unmeasured characteristics. As shown in the main body of this report, children and families who were engaged or participated in Brighter Futures were more disadvantaged and had more child protection reports compared to other families not known to child protection services. For this reason, it is reasonable to assume that child development outcomes for children whose families were engaged or participated in Brighter Futures were likely to be poor because of their family vulnerabilities rather than as an effect of participation in the Brighter Futures program itself.

Propensity score matching attempts to recreate the average equivalence between treated and control groups that would have been achieved through randomisation. Although we achieved a balance in measured characteristics between the treated and untreated groups in this study, the estimate of program effect was not substantively different using the propensity score matched groups compared with all untreated children in the study population. The nature of the variables available for use in the propensity models may have impacted on our ability to achieve equivalence between the two groups. In terms of reducing bias on treatment effect estimates, the most useful variables to include are those which predict both the treatment assignment, and the outcome of interest. Although some of the available covariates in the scoping analysis did satisfy this property, the propensity score models were ultimately not very predictive of Brighter Futures participation. This can be seen from the estimated scores plotted in Figure 22—the probability distributions are very similar for treated and untreated cases, suggesting that the models were not successful in distinguishing between participants and non-participants. The matching variables were drawn from administrative datasets, but it seems likely that these variables did not capture some of the key characteristics of families and their environments that discriminate between those families suitable for Brighter Futures versus not, and at high risk of developmental vulnerability. Families who are

eligible for Brighter Futures experience extreme markers of vulnerability, including domestic violence, drug or alcohol misuse, mental health issues, lack of parenting skills, significant learning disabilities or intellectual disability. Although we matched on a large set of characteristics, information on these extreme markers of vulnerability were not readily available in the source data. As such, the resulting control group was only superficially equivalent to the treated group, and not necessarily equivalent in terms of these more extreme underlying issues, which also impact on child development. Consequently, it is likely we were not comparing outcomes for children who participated in Brighter Futures with children growing up in similarly difficult circumstances.

Another important consideration is the pool of untreated children available for comparison. The descriptive results contained in this report indicate that children of families engaged and/or participating in Brighter Futures had higher rates of injury throughout early childhood. If the program participants were consistently the most at-risk cases it is possible that there were few or no equivalent cases remaining in the pool of untreated children in the general population. This would limit the potential for propensity matching to identify a suitable comparison group, regardless of the quality of the matching variables.

A third issue to acknowledge is the effect of stratifying by age at enrolment. This approach was appealing for two reasons: it allowed variables based on time-series data to be included in the matching; and, in the context of analysing injury outcomes, it would avoid complications arising from having both an exposure (Brighter Futures participation) and an outcome (injury) that can occur at any point in a child's early years. However, stratifying by age resulted in substantially smaller group sizes, reducing the power to detect treatment effects.

The results from this scoping analysis highlight the difficulties in retrospectively constructing a control group to estimate the effect of a program that was administered in a non-random fashion. The power of propensity score matching to correct for non-random allocation is limited to the suitability of the underlying covariate information: in this study child, family and area-level variables available in the Seeding success data resource were used, including a mixture of demographic and early life health and development variables, and some information on child protection notifications. It may be possible to get a better estimate of the Brighter Futures treatment effect if more of the markers of extreme disadvantage—domestic violence, drug or alcohol misuse, mental health issues, lack of parenting skills— that are experienced by Brighter Futures families were able to be identified from population data sets. However, information about these vulnerabilities are complex to identify in the source data, and at best, only partially available, at this time.