Potentially preventable hospitalisations for Aboriginal children with experience of out-of-home care: a data linkage study

Benjamin Harrap,[1,*] **Alison Gibberd,**[2] **Melissa O'Donnell,**[3] **Koen Simons,**[4] **Sandra Eades**[5]

[1]*Melbourne School of Population and Global Health, Level 3, The University of Melbourne, Australia*
[2]*The University of Melbourne and Hunter Medical Research Institute, Newcastle, Australia*
[3]*University of South Australia, Australia*
[4]*University of Gothenburg, Sweden*
[5]*The University of Melbourne, Australia*

Submitted: 17 June 2024; Revision requested: 11 April 2025; Accepted: 20 April 2025

Abstract

Objective: To compare potentially preventable hospitalisation (PPH) rates and types of conditions for Aboriginal children by exposure to out-of-home care (OOHC) and estimate the effect of first OOHC placement on PPH rates.

Methods: A retrospective longitudinal study of linked hospitalisation and child protection data for a matched cohort of Aboriginal children born in Western Australia between 2000 and 2013 using observed and predicted rates.

Results: Incidence rate of PPH bed days was 2.3 times higher for children ever-placed in OOHC than never-placed children. Diagnosed conditions showed no difference between ever and never-placed children across all ages. On average, PPH bed days reduced by 11% (95% confidence interval: 3% to 18%) following the first OOHC placement but never reached parity with never-placed children. For dental and otitis media-related PPHs, rates increased following first placement.

Conclusions: Children with experience of OOHC had greater rates of PPH bed days which persisted despite reductions following first OOHC placement.

Implications for Public Health: Healthcare system capacity, cultural safety, and access, as well as the material conditions of families at risk of CPS intervention, all need to be improved if rates of PPHs are to be reduced.

Key words: potentially preventable hospitalisation, out-of-home care, Aboriginal children, Western Australia, data linkage

Introduction

Potentially preventable hospitalisations (PPHs) are hospital admissions for a particular set of conditions, where the hospitalisation could have been prevented had there been access to timely primary care, social policy that provides adequate housing and resources, and health promotion to support populations to make behavioural changes that reduce the likelihood of health conditions developing.[1,2] At the individual admission level, it may be unclear whether they were actually preventable. However, at a population-level, they are useful to assess healthcare and social support systems. In Australia, the Australian Institute of Health and Welfare and state governments regularly report rates of PPHs for a variety of subpopulations, reporting that increasingly geographic remote locations[3,4] and Aboriginal and Torres Strait Islander people[5–8] typically experience higher rates of PPHs.

While government departments in Australia[5,7,9] and researchers[10,11] report rates of PPHs for both adult and child populations using an agreed set of conditions,[12] as noted in Anderson et al.,[1] many of these conditions, such as congestive cardiac failure and chronic obstructive pulmonary disease, are irrelevant for children. In their paper, the authors developed a set of conditions to identify PPHs for children and applied it to hospital admissions data in New Zealand.[13] Procter et al.[14] compare both the adult and child definitions of PPHs using Australian data, finding the child definition identified a rate more than twice as high as the adult definition, with acute bronchiolitis, acute upper respiratory tract infection excluding croup, dehydration and

*Correspondence to: Benjamin Harrap, Melbourne School of Population and Global Health, Level 3, 207 Bouverie St, The University of Melbourne, Australia; e-mail: ben.harrap@unimelb.edu.au.

Aust NZ J Public Health. 2025; Online; https://doi.org/10.1016/j.anzjph.2025.100249

gastroenteritis, and asthma being responsible for the majority of this difference.

In New Zealand, Anderson et al. also identified that PPHs might be reduced for Māori children through the implementation of government policies that adhere to the Treaty of Waitangi when making resource allocation decisions.[1] While the specifics of how New Zealand government policy interacts with the Treaty of Waitangi is unique to New Zealand, there are aspects of Australia's history and contemporary health and social support systems that underlie the disparity in the burden of disease and rate of PPHs for Aboriginal and Torres Strait Islander (hereafter Aboriginal) people. This includes evidence that Aboriginal people experience culturally unsafe services,[15] intergenerational trauma,[16] and institutional racism,[17] which are consequences of historic and ongoing colonisation.[18,19] The interplay of these aspects has resulted in Aboriginal people being more likely to experience higher levels of overcrowded housing and poorer socio-economic outcomes which lead to the inequitable burden of disease and higher rates of PPHs. An example of this is that even with the introduction of health checks specifically for Aboriginal people in 2006 and a large increase in usage of these checks from 2009 to 2019,[6,9] Aboriginal people still experience disparity in rates of PPHs.[5]

Given the overrepresentation of Aboriginal children in the child protection system is now a key issue in Australia's national commitment to Closing the Gap,[20] and evidence that many families involved in child protection are also from socio-economically disadvantaged areas,[21–23] it is important that we understand more about PPHs for children with experience of child protective services. This research is part of a broader Aboriginal-led study, Indigenous Child Removals Western Australia (I-CaRe WA),[24] which aims to identify factors that reduce the number of Aboriginal children going into out-of-home care (OOHC) and ways to better support families at risk, children in care and kinship carers. In qualitative interviews conducted as part of this study, kinship carers spoke of difficulties in accessing appropriate primary healthcare for children in their care. Staff at Aboriginal community-controlled health organisations also reported that the funding allocated to Aboriginal child health checks was insufficient to cover the time required to address the complex health needs of children in OOHC.[25] Our work on the I-CaRe WA study also found that the prevalence of mental and neurodevelopmental health conditions was higher for Aboriginal children with experience of OOHC than Aboriginal children who were never removed.[26] The study's qualitative findings that Aboriginal children in OOHC had increased health needs, their parents and carers had difficulty accessing primary healthcare, and primary healthcare services were under-resourced,[25] appears to put these children at greater risk of having PPHs; however, this has not previously been examined at a population-level.

Given this gap in the literature, we had three aims, the first two being descriptive. Our first aim was, for Aboriginal children born in Western Australia, to compare the rate of PPHs for Aboriginal children who were ever-placed in OOHC to Aboriginal children who were never-placed. We wanted to identify whether children with experience of OOHC had an increased rate of PPHs. Our second aim was to explore the conditions resulting in PPHs as the mechanisms for prevention vary.[1] Our third aim was to examine the causal effect of placement in OOHC on rates of PPHs.

Methods and data

Data and cohort

The cohort for this study was derived from a data linkage of all Aboriginal children born in Western Australia between 2000 and 2013. Data were obtained via data linkage using probabilistic matching[27] provided by Data Linkage Services Western Australia. Placements in OOHC were identified using child protection data from the Western Australian Department of Communities covering 2000 to 2019. Birth and death records were obtained from the Midwives Notification System, Birth Registrations, and Death Registrations. Admissions were identified using the Hospital Morbidity Data Collection (HMDC) and Emergency Department Data Collection (EDDC), both covering the 2000 to 2019 period. Stillbirths and children who died before 29 days old were excluded.

PPHs, hospitalisation periods, placement periods

PPHs were identified using primary diagnoses in the HMDC only, according to the set of conditions in Table 2 of Anderson et al.[1] for children aged 29 days to 14 years. We restricted diagnosis to only HMDC records because diagnostic coding is completed by trained clinical coding staff who review patient records to determine primary diagnoses according to the ICD-10-AM, whereas this is not the case for the EDDC.

Both the HMDC and EDDC were used to identify hospitalisation periods. We defined a hospitalisation period to be the continuous period of time from when an individual is first admitted to an emergency department or hospital to when they are discharged due to no longer receiving medical care at one of these facilities. Hospitalisation periods potentially spanned multiple records and facilities across the EDDC and HMDC due to transfers or re-admissions. See the Supplementary Materials for details on how these periods were identified. These hospitalisation periods then formed the basis of our analyses, where we examine both the number of bed days and admissions.

Analysis methods

Analyses were performed using R[28] and RStudio.[29] We used the *MatchIt* package[30] to match never-placed children to ever-placed children in a 2:1 ratio. Matching was based on month–year of birth (e.g. 07-2004), 2011 remoteness area[31] of their mother's address at the time of their birth, and 2011 state-level index of relative socio-economic advantage and disadvantage[32] (IRSAD, hereafter referred to as socio-economic area). Optimal pair matching[33] with the Mahalanobis distance and exact matching on month–year of birth was used, which minimises the sum of the absolute pairwise distances in the matched sample. Matching on month–year of birth ensured follow-up time was comparable for the never- and ever-placed groups and minimised the impact of changing healthcare practices on PPHs, such as the rotavirus vaccine being introduced for children in 2007.[34] Remoteness area and socio-economic area were matched given that they both influence rates of PPHs and placements into OOHC.[12,35]

Aim 1—Descriptive comparison of PPH rates

We stratified our descriptive analyses by five-year age brackets (29 days to 4 years old, 5 to 9 years old and 10 to 14 years old) consistent with reporting elsewhere[5,13] and one-year age increments. Hospitalisation periods that overlapped two age brackets contributed time to each age bracket accordingly. Similarly, hospitalisation periods that overlapped the first placement in OOHC contributed to pre- and post-placement time accordingly. Rates of bed days for PPHs were calculated using the *epi2x2* function from the *epiR* package[36] and were based on total bed days spent in a hospitalisation period and total time at risk. Time at risk was calculated as the total observed time in a given age bracket, with follow-up time being censored at the end of 2019, or on a child's 15th birthday or date of death if these occurred prior to the end of 2019.

Aim 2—Descriptive comparison of PPH conditions

The frequency of PPH conditions was based on the primary diagnosis of each individual HMDC record within a hospitalisation period. For example, a hospitalisation period containing two records where these records' primary diagnoses were acute bronchiolitis and asthma would contribute to the count of both acute bronchiolitis and asthma, despite being considered one hospitalisation period.

Aim 3—Estimate the causal effect of placement in OOHC on PPH rates

To estimate the average causal effect of placement in OOHC on the rate of PPH bed days we used mixed effects regression with random intercepts at the individual level and follow-up time as an offset, using the *glmmTMB* package.[37] We included ever- or never-placed status, an indicator for pre/post-first placement in care, and an interaction term between these two variables. We also included age, remoteness area, and socio-economic area in the model. By matching and assigning the same date of first placement in OOHC to never-placed children as the ever-placed child they were matched to, we treat never-placed children as a counterfactual control group. Although age, remoteness area, and socio-economic status were matching variables, they were also included in the model for potential gains in model accuracy and to estimate marginal rates of hospitalisations across different levels of these variables. Since PPH conditions have differing etiologies, we also ran individual regression models to assess the relationship between placement in OOHC and bed days for respiratory conditions (asthma and acute upper respiratory tract infections), skin infections, dental issues, pneumonia, gastroenteritis, and otitis media.

Age and socio-economic area were assessed for their optimal functional forms as multivariable fractional polynomials via the *mfp2* package.[38] Poisson or negative binomial distributions with a log link were used, depending on the presence of over-dispersion.

Results

After excluding 181 children who died in the first 28 days of life and 125 who had missing data on the matching variables, a total of 33,403 children born between 2000 and 2013 were included in the matching process. There were 3,721 ever-placed children who were matched with 7,442 never-placed children. For remoteness area, 98.6% of never-placed children shared the same value as their ever-placed matched counterpart, with 1.4% being 1 rating away. For socio-economic area, 94.9% shared the same value, 4.9% were within one decile.

Table 1 presents demographic and hospital admission characteristics for the two groups. The never-placed cohort had an average of 5.9 hospitalisation periods per child (43,962 periods divided by 7,442 children) compared with 7.9 for ever-placed children (29,369 divided by 3,721). For PPH periods, the average was 1 per never-placed child compared with 1.7 per ever-placed child. Almost all children in both cohorts had at least one hospital record, while half of never-placed children (48.9 %) had at least one PPH compared with 63.7% of ever-placed children. The mean and median number of bed days for PPHs were 4.42 and 3 for ever-placed children, respectively, for never-placed children these were 3.28 and 2, respectively. The mean and median number of admissions for PPHs were 2.74 and 2, respectively, for ever-placed children, for never-placed children it was 2.1 and 1, respectively.

Aim 1—Descriptive comparison of PPH rates

Table 2 presents the incidence rate of hospital bed days per 1,000 days at risk, and incidence rate ratios for each age bracket and overall, according to ever- or never-placed group. For both groups, the incidence rate was highest for the 0–4 age group, with the rate declining with increasing age. Overall, the rate of PPH bed days for ever-placed children was 2.3 times higher compared with never-placed children and the rate of PPH admissions was 1.7 times higher (see Supplementary Materials). At no age were the incidence rates near parity between ever- and never-placed children. The age at which the rate of PPH bed days was highest was during infancy at 3.50 per 1,000 days at risk for never-placed children and more than twice as high at 8.12 per 1,000 days at risk for ever-placed children.

Aim 2—Descriptive comparison of PPH conditions

Table 3 highlights the ten most common PPH conditions for ever- and never-placed children in each age bracket (see the Supplementary

Table 1: Demographic and other characteristics for the matched cohort of never- and ever-placed children.

	Never-placed	Ever-placed
N	7,442	3,721
Socio-economic area at birth 1st quintile (most disadvantaged)	3,559 (47.8 %)	1,781 (47.9 %)
2nd quintile	1,336 (18.0 %)	675 (18.1 %)
3rd quintile	1,717 (23.1 %)	836 (22.5 %)
4th quintile	655 (8.8 %)	334 (9.0 %)
5th quintile (most advantaged)	175 (2.4 %)	95 (2.6 %)
Remoteness area at birth Major cities	3,802 (51.1 %)	1,899 (51.0 %)
Inner regional	368 (4.9 %)	189 (5.1 %)
Outer regional	1,101 (14.8 %)	552 (14.8 %)
Remote	1,371 (18.4 %)	671 (18.0 %)
Very remote	800 (10.7 %)	410 (11.0 %)
Missing	3,802 (51.1 %)	1,899 (51.0 %)
Number of hospital periods for any condition All ages	43,962	29,369
Ages 0–4	22,048 (50.2 %)	15,586 (53.1 %)
Ages 5–9	12,997 (29.6 %)	7,576 (25.8 %)
Ages 10–14	8,913 (20.3 %)	6,207 (21.1 %)
Number of PPH hospital periods All ages	7,630	6,491
Ages 0–4	5,366 (70.3 %)	4,850 (74.7 %)
Ages 5–9	1,752 (23 %)	1,227 (18.9 %)
Ages 10–14	512 (6.7 %)	414 (6.4 %)
Number of children with at least one hospital period For any condition	6,683 (89.8 %)	3,565 (95.8 %)
For PPH condition	3,638 (48.9 %)	2,369 (63.7 %)

[1]All hospital periods include both emergency department and hospital records.

PPH, potentially preventable hospitalisation.

Table 2: Rates of PPHs per 1,000 person-days at risk and incidence rate ratios, by placement group and age, for Aboriginal children born in Western Australia between 2000 and 2013.

Age group	Never-placed children			Ever-placed children			Incidence rate ratio
	PPH days	Days at risk	Incidence rate	PPH days	Days at risk	Incidence rate	
0–4	**18,743**	**13,362,678**	**1.40 (1.38 to 1.42)**	**22,279**	**6,618,603**	**3.37 (3.32 to 3.41)**	**2.4 (2.4 to 2.4)**
0	8,779	2,511,817	3.50 (3.42 to 3.57)	10,099	1,243,038	8.12 (7.97 to 8.28)	2.3 (2.3 to 2.4)
1	4,953	2,709,182	1.83 (1.78 to 1.88)	6,897	1,341,549	5.14 (5.02 to 5.26)	2.8 (2.7 to 2.9)
2	2,061	2,705,837	0.76 (0.73 to 0.80)	2,628	1,341,158	1.96 (1.89 to 2.04)	2.6 (2.4 to 2.7)
3	1,674	2,703,718	0.62 (0.59 to 0.65)	1,364	1,339,569	1.02 (0.96 to 1.07)	1.6 (1.5 to 1.8)
4	1,276	2,702,404	0.47 (0.45 to 0.50)	1,291	1,338,567	0.96 (0.91 to 1.02)	2 (1.9 to 2.2)
5–9	**4,729**	**12,258,091**	**0.39 (0.37 to 0.40)**	**4,057**	**6,061,206**	**0.67 (0.65 to 0.69)**	**1.7 (1.7 to 1.8)**
5	1,279	2,701,566	0.47 (0.45 to 0.50)	1,451	1,338,053	1.08 (1.03 to 1.14)	2.3 (2.1 to 2.5)
6	1,214	2,628,699	0.46 (0.44 to 0.49)	903	1,301,725	0.69 (0.65 to 0.74)	1.5 (1.4 to 1.6)
7	856	2,477,027	0.35 (0.32 to 0.37)	694	1,224,675	0.57 (0.53 to 0.61)	1.6 (1.5 to 1.8)
8	643	2,303,830	0.28 (0.26 to 0.30)	559	1,137,566	0.49 (0.45 to 0.53)	1.8 (1.6 to 2.0)
9	737	2,119,935	0.35 (0.32 to 0.37)	450	1,045,819	0.43 (0.39 to 0.47)	1.2 (1.1 to 1.4)
10–14	**1,745**	**7,489,180**	**0.23 (0.22 to 0.24)**	**2,124**	**3,680,014**	**0.58 (0.55 to 0.60)**	**2.5 (2.3 to 2.6)**
10	539	1,935,665	0.28 (0.26 to 0.30)	522	955,179	0.55 (0.50 to 0.60)	2 (1.7 to 2.2)
11	454	1,719,735	0.26 (0.24 to 0.29)	381	847,190	0.45 (0.41 to 0.50)	1.7 (1.5 to 2.0)
12	406	1,496,527	0.27 (0.25 to 0.30)	370	734,763	0.50 (0.45 to 0.56)	1.9 (1.6 to 2.1)
13	220	1,266,580	0.17 (0.15 to 0.20)	284	620,487	0.46 (0.41 to 0.51)	2.6 (2.2 to 3.2)
14	126	1,054,253	0.12 (0.10 to 0.14)	567	514,329	1.10 (1.01 to 1.20)	9.2 (7.6 to 11.3)
All	**25,217**	**33,109,949**	**0.76 (0.75 to 0.77)**	**28,460**	**16,359,823**	**1.74 (1.72 to 1.76)**	**2.3 (2.2 to 2.3)**

[1]Incidence rates and incidence rate ratios are presented as estimate (95 % confidence interval).
[2]The increased incidence rate for ever-placed children aged 14–15 years was primarily driven by a small number of hospitalisation periods accounting for approximately 50 % of PPH days.
PPH, potentially preventable hospitalisation.

Materials for all PPH conditions). The mix of conditions was very similar for both ever- and never-placed children. For the age 0–4 period, acute bronchiolitis was the most commonly identified condition, accounting for almost 20% of identified conditions for both never- and ever-placed children. Respiratory conditions were common across all ages, with acute upper respiratory tract infection (excluding croup) and asthma accounting for between 10 to 15% of conditions for both ever- and never-placed children. Dental conditions were also common across all ages but appeared most frequently in the 5–9 age group, accounting for around a quarter of diagnoses. Similarly, skin infections were common across all age brackets, but increased as a proportion of conditions with age and accounted for at least a quarter of the conditions identified in the 10–14 age bracket. Gastroenteritis was much more common for ages 0–4 at around 17% of diagnoses.

Aim 3—Estimate the causal effect of placement in OOHC on PPH rates

Table 4 presents the incidence rates and rate ratios for PPH bed days before and after ever-placed children's first placement in OOHC.

Table 3: Frequency of the ten most common potentially preventable hospitalisation diagnoses within each 5-year age group.

Diagnosis	Ages 0–4 N = 10,541		Ages 5–9 N = 3,016		Ages 10–14 N = 960	
	Never-placed	Ever-placed	Never-placed	Ever-placed	Never-placed	Ever-placed
Acute Bronchiolitis	1,082 (19.9 %)	1,020 (21.0 %)				
Acute rheumatic fever					28 (5.4 %)	21 (5.1 %)
Acute Upper Respiratory Tract Infection Excluding Croup	562 (10.3 %)	516 (10.6 %)	84 (4.8 %)	59 (4.8 %)	37 (7.1 %)	28 (6.8 %)
Asthma	376 (6.9 %)	307 (6.3 %)	118 (6.7 %)	61 (5.0 %)	38 (7.3 %)	16 (3.9 %)
Bacterial/Pneumonia	456 (8.4 %)	430 (8.8 %)	109 (6.2 %)	80 (6.5 %)	23 (4.4 %)	41 (9.9 %)
Constipation			25 (1.4 %)	33 (2.7 %)	21 (4.0 %)	12 (2.9 %)
Dental (Dental Caries/pulp/periodontal)	425 (7.8 %)	260 (5.3 %)	435 (24.7 %)	287 (23.3 %)	53 (10.1 %)	49 (11.8 %)
Gastroenteritis	918 (16.9 %)	801 (16.5 %)	119 (6.7 %)	60 (4.9 %)	36 (6.9 %)	16 (3.9 %)
Otitis Media	438 (8.0 %)	505 (10.4 %)	286 (16.2 %)	240 (19.5 %)	61 (11.7 %)	46 (11.1 %)
Skin Infection	494 (9.1 %)	454 (9.3 %)	379 (21.5 %)	244 (19.8 %)	142 (27.2 %)	105 (25.4 %)
Urinary Tract Infection			44 (2.5 %)	42 (3.4 %)	23 (4.4 %)	23 (5.6 %)
Viral Infection of unspecified site	237 (4.4 %)	190 (3.9 %)	46 (2.6 %)	50 (4.1 %)		
Viral Pneumonia	59 (1.1 %)	74 (1.5 %)				

[1]N's represent number of hospitalisation periods for a given age group.
[2]Percentages reported are based on the total count of PPH conditions within each age period.

Table 4: Rates of PPHs per 1,000 person-days and incidence rate ratios for pre- and post-first placement in out-of-home care by age group, for Aboriginal children born in Western Australia between 2000 and 2013.

Age group	Pre-first placement			Post-first placement			Incidence rate ratio
	PPH days	Days at risk	Incidence rate	PPH days	Days at risk	Incidence rate	
0–4	**15,268**	**3,654,649**	**4.18 (4.11 to 4.24)**	**6,950**	**2,963,954**	**2.34 (2.29 to 2.40)**	**0.6 (0.5 to 0.6)**
0	7,973	971,031	8.21 (8.03 to 8.39)	2,091	272,007	7.69 (7.36 to 8.02)	0.9 (0.9 to 1.0)
1	4,794	853,398	5.62 (5.46 to 5.78)	2,095	488,151	4.29 (4.11 to 4.48)	0.8 (0.7 to 0.8)
2	1,457	716,467	2.03 (1.93 to 2.14)	1,163	624,691	1.86 (1.76 to 1.97)	0.9 (0.8 to 1.0)
3	500	602,722	0.83 (0.76 to 0.91)	864	736,847	1.17 (1.10 to 1.25)	1.4 (1.3 to 1.6)
4	544	503,012	1.08 (0.99 to 1.18)	737	835,555	0.88 (0.82 to 0.95)	0.8 (0.7 to 0.9)
5–9	**1,307**	**1,394,556**	**0.94 (0.89 to 0.99)**	**2,750**	**4,666,650**	**0.59 (0.57 to 0.61)**	**0.6 (0.6 to 0.7)**
5	679	417,891	1.62 (1.50 to 1.75)	772	920,162	0.84 (0.78 to 0.90)	0.5 (0.5 to 0.6)
6	298	338,830	0.88 (0.78 to 0.99)	605	962,895	0.63 (0.58 to 0.68)	0.7 (0.6 to 0.8)
7	110	265,879	0.41 (0.34 to 0.50)	584	958,796	0.61 (0.56 to 0.66)	1.5 (1.2 to 1.8)
8	146	208,719	0.70 (0.59 to 0.82)	413	928,847	0.44 (0.40 to 0.49)	0.6 (0.5 to 0.8)
9	74	160,227	0.46 (0.36 to 0.58)	376	885,592	0.42 (0.38 to 0.47)	0.9 (0.7 to 1.2)
10–14	**186**	**246,277**	**0.76 (0.65 to 0.87)**	**1,938**	**3,433,737**	**0.56 (0.54 to 0.59)**	**0.7 (0.6 to 0.9)**
10	63	112,064	0.56 (0.43 to 0.72)	459	843,115	0.54 (0.50 to 0.60)	1.0 (0.7 to 1.3)
11	39	71,714	0.54 (0.39 to 0.74)	342	775,476	0.44 (0.40 to 0.49)	0.8 (0.6 to 1.2)
12	11	41,141	0.27 (0.13 to 0.48)	359	693,622	0.52 (0.47 to 0.57)	1.9 (1.1 to 3.9)
13	67	16,939	3.96 (3.07 to 5.02)	217	603,548	0.36 (0.31 to 0.41)	0.1 (0.1 to 0.1)
14	6	3,921	1.53 (0.56 to 3.33)	561	510,408	1.10 (1.01 to 1.19)	0.7 (0.3 to 2.0)

[1]Incidence rates and incidence rate ratios are presented as estimate (95 % confidence interval).
PPH, potentially preventable hospitalisation.

Consistent with Table 2, the incidence rate of PPH bed days reduced with age, being highest in the first year of life and ages 0-4 generally.

Our modelling of the effect of first placement in OOHC on the rate of bed days for PPHs for ever-placed children provided an estimated incidence rate ratio of 0.89 (95% CI: 0.82 to 0.97), suggesting that on average the rate of PPH bed days reduced by 11% (95% CI: 3% to 18%) in the period following a child's first placement in OOHC, with a reduction ranging from 3% to 18% also being plausible. Examining the marginal rate of PPH bed days per 1,000 days at risk for children aged 1 to 14 and across remoteness areas (**Figure 1**), found that the estimated difference between before and after first placement in OOHC was greatest in the first year of life. For all children, increasing age was the largest driver for reductions in the rate of PPH bed days, with the rate falling most rapidly from ages one to five. Increasing remoteness was associated with an increase in the rate of bed days for never- and ever-placed children.

Results of the regression modelling for specific health conditions suggested that placement had a differential impact on the rate of PPHs according to the type of condition. The incidence rate ratio estimates for the effect of placement in OOHC for the conditions assessed were:

- Asthma and acute upper respiratory tract infections: 0.74 (95% CI: 0.6 to 0.93)
  - Dental conditions: 2.26 (95% CI: 1.73 to 2.95)
  - Gastroenteritis: 0.75 (95% CI: 0.6 to 0.95)
  - Otitis media: 1.72 (95% CI: 1.33 to 2.23)
  - Pneumonia: 0.74 (95% CI: 0.56 to 0.99)
  - Skin infection: 0.65 (95% CI: 0.53 to 0.81)

The estimated marginal rates of bed days for each conditions across age per 100,000 days at risk are presented in **Figure 2**. The point estimates for skin infections, respiratory conditions, gastroenteritis, and pneumonia suggest reductions in the rates of these conditions post-placement; however, the confidence intervals for the effect of placement in OOHC on rates of bed days for respiratory conditions, gastroenteritis, and pneumonia were compatible with no effect or a small increase. For dental conditions and otitis media, the estimates suggested that placement in OOHC increased the rate of PPH bed days.

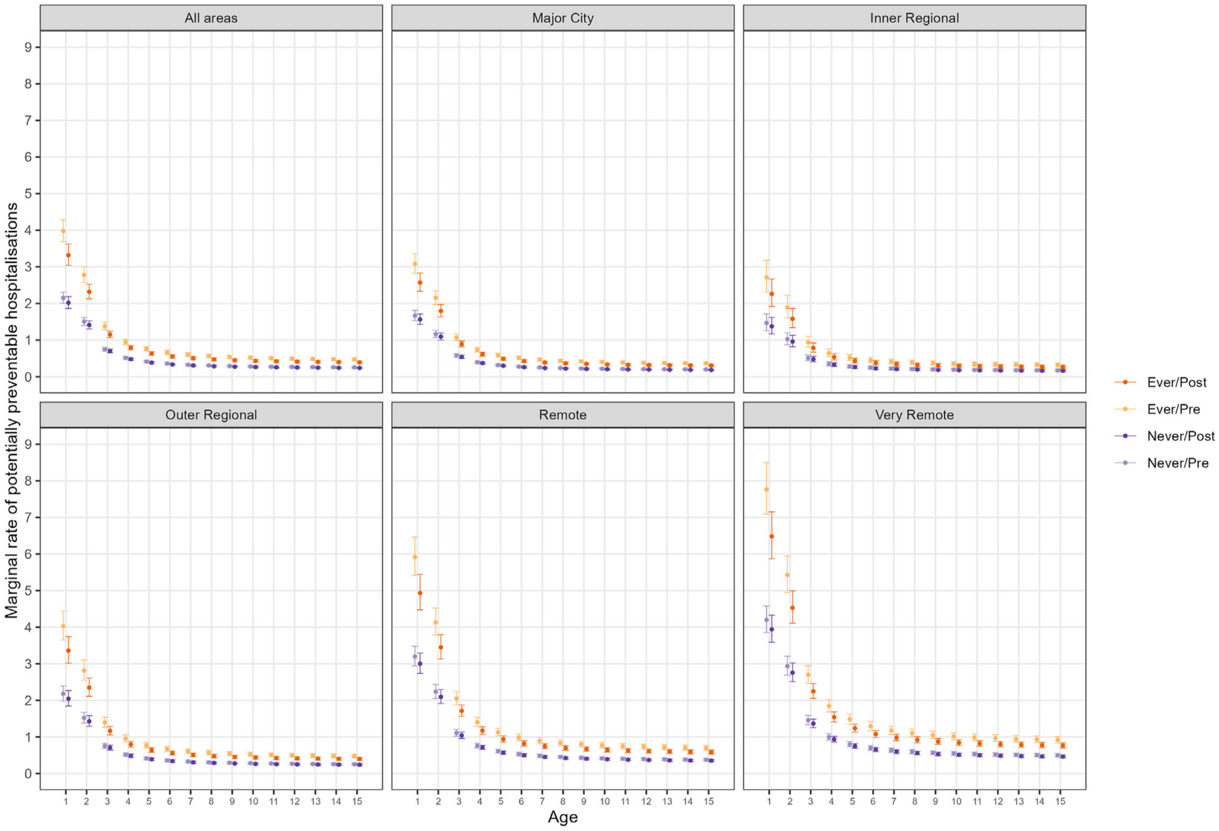
In both Figure 1 and Figure 2, the marginal rates pre- and post-placement are displayed for never-placed children despite them not actually being placed, to allow for a comparison of marginal rates.

Discussion

Our study found that across all ages, Aboriginal children born in Western Australia who were ever-placed in OOHC had higher rates of PPHs than Aboriginal children who were not placed in OOHC. Rates of PPH bed days were approximately two times higher for ever-placed children and increased with increasing remoteness, consistent with existing research.[3,39] The highest rate of PPHs generally occurred during the first year of life for all children, similar to findings from South Australia[14,39] and New South Wales.[8] That the highest rates of placement in OOHC also occur in the first year of life[40] highlights the need for wrap-around services for Aboriginal children and their families at risk of child protection involvement to help prevent children being removed and enable their families to access primary healthcare.

As a proportion of all PPH conditions observed for ever- and never-placed children, the distribution of conditions was almost identical, indicating that the types of conditions resulting in PPHs for Aboriginal children born in Western Australia are characteristically similar regardless of CPS involvement; ever-placed children simply had more

Figure 1: Estimates and 95 % confidence intervals of the marginal rate of PPH bed days from ages 0 to 14 years for ever- and never-placed Aboriginal children pre- and post-first placement, for the most socio-economically disadvantaged decile. PPH, potentially preventable hospitalisation.



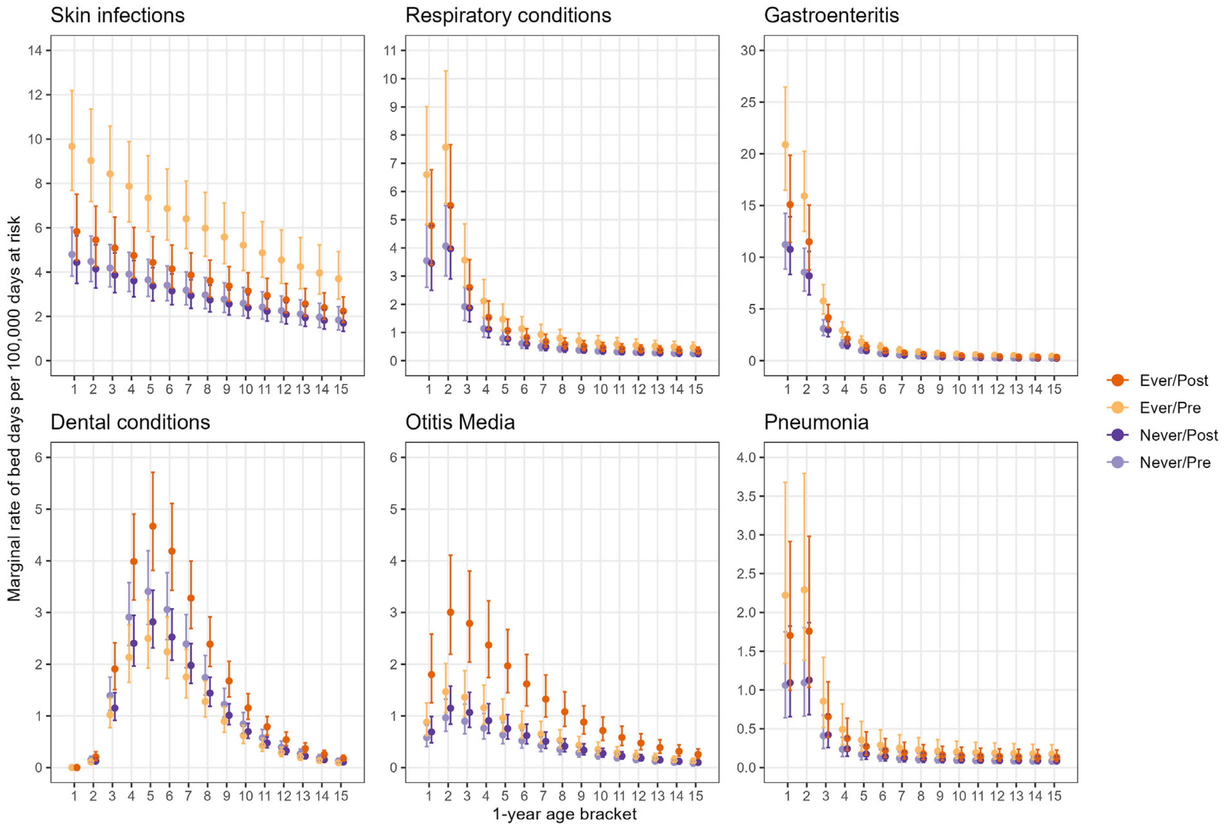
PPHs. The most common conditions we observed were largely the same as seen in data-linkage studies from South Australia[14] and New South Wales.[8] That dental, respiratory, dermatological, and hearing problems were among the most common conditions is also consistent with reviews of specialist referrals for Aboriginal children undergoing health screening upon being placed in OOHC in Sydney[41] and Melbourne.[42]

When estimating the effect of placement in OOHC on the most common PPH conditions, our estimates of the marginal rates of bed days included no effect as a plausible outcome but were mostly consistent with placement reducing rates of PPH bed days for skin infections, respiratory conditions, gastroenteritis, and pneumonia. The finding that the rate of PPH bed days for dental conditions and otitis media increased post-placement was unexpected. One explanation may be that dental conditions developed during the pre-placement period but were only identified during health checks upon entry into OOHC, leading to treatment being sought by carers and enabled by CPS, resulting in an increase in rates of dental-related PPHs. The estimates of the marginal rates 'post-placement' for never-placed children are different to their rates 'pre-placement' which is likely the effect of age, but there may be another underlying reason we have not identified.

When considering the mechanisms for prevention suggested by Anderson et al.,[1] most conditions were preventable through early access to primary care. Only dental conditions, gastroenteritis, and skin infections were considered preventable through health promotion. However, these conditions constituted 30%–50 % of conditions across the three age brackets, suggesting health promotion can play an important role in policy design to reduce rates of these PPHs. Underlying this, however, is our finding that the rate of PPHs increased with increasing socio-economic disadvantage. If the household environment and access to timely primary healthcare are dependent on financial capacity, such as paying for housing with more bedrooms to avoid overcrowding or visiting general practitioners and dentists that charge gap fees to access them earlier, the influence of health promotion will be limited for the most socio-economically disadvantaged families while financial barriers exist. Screening for healthcare needs, referrals to specialists, changing household environment and no longer being maltreated could all contribute to lower rates of PPHs. What is important to realise is that these preventive measures can all occur without having to remove a child from their family—through early intervention and support services for families.

While we observed a decrease in the rates of PPHs for children following their first placement in OOHC, their rate of PPHs never reached parity with never-placed children despite matching on remoteness area and socio-economic area at birth. There could be several reasons for this. Chronic or long-developing health conditions, such as asthma or dental caries, might have developed during the pre-placement period as a consequence of adverse social circumstances, maltreatment or neglect, or systemic racism affecting access to, and experiences in, healthcare or leading to entrenched

Figure 2: Estimates and 95 % confidence intervals of the marginal rate of PPH bed days from ages 0 to 14 for ever- and never-placed Aboriginal children pre- and post-first placement, by diagnosed condition, for major city areas and most disadvantaged IRSAD decile. PPH, potentially preventable hospitalisation; IRSAD, index of relative socio-economic advantage and disadvantage.



poverty; all of which would make these conditions more likely to appear in hospital data since the underlying prevalence of these conditions is higher. Another explanation could be that upon being reunified with their parents, children return to housing conditions or environments that put them at greater risk of having a PPH, such as smoking in the home, overcrowded housing, or parents facing financial and structural barriers to accessing care. However, the majority of children do not get reunified,[43] suggesting that the financial and social support that carers receive from CPS is inadequate to overcome barriers in accessing healthcare for children in their care.

The availability of appointments and ability of parents or carers to access them is a critical issue, with 30% of Aboriginal people in WA stating they had not sought healthcare despite needing to, with transport, distance, and wait times being common reasons.[6] The often excessive waiting times encountered by families in the child development services system[44] are also inconsistent with the principle of early and timely intervention, with this interim report highlighting the very real impacts of excessive waiting times on children, families and their wider networks, as well as on child development services practitioners. Access to healthcare services is therefore a priority issue for all children, and particularly for children in OOHC, where improved access combined with the elimination of systemic racism in healthcare services can lead to better health for all Aboriginal and Torres Strait Islander children[45,46] and reduced rates of placements into OOHC.

The First Nations-specific health check[9] and health check upon entry into OOHC[47] presume a medical professional is available to provide a high-quality service, meaning there is a need to ensure the healthcare system has sufficient capacity to carry out these health care services, in particular in remote areas where the highest rates of PPHs are occurring. Increasing the number of Aboriginal medical graduates will be especially important to improve the delivery of culturally safe services, whether in an Aboriginal medical service or elsewhere. There is also an ongoing pilot of a health navigator program in WA for children in OOHC. For Aboriginal children, this program seeks to improve coordination between services and create a trauma-informed, culturally safe environment informed by Aboriginal voices.[48,49] This may provide a framework for broader implementation, creating services that recognise culture as a protective factor and treat individuals in the holistic context of their family, kinship and community.

Cost of healthcare services is still an important factor. Given that PPHs are more common for people with lower socio-economic backgrounds[3] and the decline in bulk-billing medical clinics in Australia generally,[50] increasing out-of-pocket costs will continue to play a role in the decision to visit emergency departments over primary care, with 43% of Indigenous people in Western Australia reporting cost as the main reason for not seeking healthcare when it was needed.[6] Given the average cost of a hospital bed day in Western Australia was $2,370 in 2022,[51] any investment by state or federal government targeted at improving access to primary healthcare will, in addition to improving the health of children generally, likely be offset by a reduction in admissions.[52]

Limitations

Children are identified as ever-placed if their first contact with CPS occurred between 2000 and July 2015. Those whose first contact was after July 2015 would be incorrectly classified as never-placed. We estimate this to be approximately two percent of the cohort, given the rate of placement for children after the age of four in our previous research.[40] Given the percent misclassified is likely small, and the misclassification will make the groups more comparable such that any estimates would be attenuated, we do not believe this has a major impact on our findings.

Future research

Based on our directed acyclic graph, we identified several confounding variables that could bias estimates of the relationship between OOHC and rates of PPH bed days, such as housing and family domestic violence. While unmeasured confounding is a fundamental problem of causal inference using observational data, including additional datasets that have information on these confounding variables in a future data linkage would help understand their impact.

As a measure, PPHs, even when designed for use in younger populations, are limited in that the actual hospitalisations may not have been preventable. While policy recommendations to improve access to primary care makes sense at face value, finding out the reasons why parents or carers of Aboriginal children with child protection involvement are attending emergency departments and hospitals for PPHs may yield information that makes policy design and interventions more effective.

Conclusion

As identified, existing research has only examined rates of PPHs by OOHC experience for all children or for Aboriginal children without considering OOHC experience. This research therefore contributes a key piece currently missing from the Australian literature by being the first to examine PPHs for Aboriginal children who enter OOHC; finding that Aboriginal children with experience of OOHC have greater rates of PPHs than never-placed Aboriginal children and the rate of PPHs reduces following first placement into OOHC.

While the current strain on the healthcare system affects all Australians, Aboriginal children and in particular Aboriginal children who are placed in out-of-home care are particularly impacted. Our findings that the types of conditions experienced by Aboriginal children who enter OOHC does not differ from Aboriginal children more broadly, and that rates of potentially preventable hospitalisations after intervention by child protective services do not reach parity with Aboriginal children who are never-placed in OOHC, highlights that there is additional need for support for parents and carers of Aboriginal children already in, or at risk of entering, OOHC. Addressing these needs will require the support and funding of Aboriginal-led solutions as Aboriginal communities are best positioned to identify and address their needs.

Conflicts of interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Sandra Eades reports financial support was provided by the National Health and Medical Research Council. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Funding

The project was funded by the NHMRC Project Grant 1162968.

Ethics approval

Ethical approval for the I-CaRe WA project was given by the Western Australian Aboriginal Human Ethics Committee (943) and the Department of Health Human Research Ethics Committee (RGS 3496).

Acknowledgments

The primary author, Benjamin Harrap, is not an Aboriginal or Torres Strait Islander person. The I-CaRe WA study is an Aboriginal-led study which engages Aboriginal voices through its leadership and through study advisory, policy and community reference groups. The authors would like to thank the members of these groups for their feedback and contributions to the formation of this article.

The authors wish to thank the staff at DLSWA and the custodians of the Midwives Notification System, Birth Registrations, Death Registrations, Hospital Morbidity Data Collection, Emergency Department Data Collection, and child protection datasets. The information presented does not reflect the views of DLSWA or any of the data custodians.

Author ORCIDs

Benjamin Harrap https://orcid.org/0000-0002-0889-6214
Alison Gibberd https://orcid.org/0000-0002-1689-1798
Koen Simons https://orcid.org/0000-0002-6534-2277

References

1. Anderson P, Craig E, Jackson G, Jackson C. Developing a tool to monitor potentially avoidable and ambulatory care sensitive hospitalisations in New Zealand children. *The New Zealand Medical Journal* 2012;**125**(1366).
2. Falster M, Jorm L. *A guide to the potentially preventable hospitalisations indicator in Australia*. Sydney: Centre for Big Data Research in Health, University of New South Wales in consultation with Australian Commission on Safety and Quality in Health Care and Australian Institute of Health and Welfare; 2017.
3. Australian Institute of Health and Welfare. *Aboriginal and Torres Strait Islander health performance framework 2020 summary report. Cat. No. IHPF 2*. Canberra: AIHW; 2020.
4. Duckett S, Griffiths K. *Perils of place: identifying hotspots of health inequalities*. Melbourne: Grattan Institute; 2016. Available from: https://grattan.edu.au/wp-content/uploads/2016/07/874-Perils-of-Place.pdf.
5. Australian Institute of Health and Welfare. *Disparities in potentially preventable hospitalisations across Australia, 2012–13 to 2017–18*. Canberra: AIHW; 2020. https://www.aihw.gov.au/getmedia/20bc5bf9-d46c-40a7-96c1-d632a1d448bc/aihw-hpf-50.pdf.
6. Australian Institute of Health and Welfare. *Aboriginal and Torres Strait Islander health performance framework 2020 key health indicators—western Australia. Cat. No. IHPF 9*. Canberra: AIHW; 2020.
7. Department of Health Western Australia. *Lessons of location: potentially preventable hospitalisation hotspots in western Australia 2017*. 2017. Perth.
8. Falster K, Banks E, Lujic S, Falster M, Lynch J, Zwi K, et al. Inequalities in pediatric avoidable hospitalizations between Aboriginal and non-Aboriginal children in Australia: a population data linkage study. *BMC Pediatr* 2016;**16**(1):1–12.

9. Australian Health Ministers' Advisory Council. *Aboriginal and Torres Strait Islander health performance framework 2017 report*. 2017. Canberra, https://www.niaa.gov.au/sites/default/files/publications/2017-health-performance-framework-report_1.pdf.
10. Li SQ, Gray NJ, Guthridge SL, Pircher SL. Avoidable hospitalisation in aboriginal and non-aboriginal people in the northern territory. *Med J Aust* 2009;**190**(10):532–6.
11. Guthrie J. Estimating the magnitude of potentially avoidable hospitalisations of Indigenous children in the Australian capital territory: some methodological challenges. *Aust Aborig Stud* 2012;(1):92–7. Available from: https://search.informit.org/doi/10.3316/informit.407306360938004.
12. Australian Institute of Health and Welfare. *National healthcare agreement: PI 18–selected potentially preventable hospitalisations*. Canberra: AIHW; 2022.
13. Craig E, Anderson P, Jackson G, Jackson C. Measuring potentially avoidable and ambulatory care sensitive hospitalisations in New Zealand children using a newly developed tool. *N Z Med J* 2012;**125**(1366).
14. Procter AM, Pilkington RM, Lynch JW, Smithers LG, Chittleborough CR. Potentially preventable hospitalisations in children: a comparison of definitions. *Arch Dis Child* 2020;**105**(4):375–81.
15. Liddle C, Gray P, Burton J, Prideaux C, Solomon N, Cackett J, et al. *The Family Matters report*. 2021.
16. Human Rights and Equal Opportunity Commission. *Bringing Them Home. National Inquiry Into the Separation of Aboriginal and Torres Strait Islander Children from Their Families*. 1997.
17. Tilbury C. Aboriginal and Torres Strait Islander families in Australia: poverty and child welfare involvement. In: *Theoretical and empirical insights into child and family poverty*. Springer; 2015. p. 273–84.
18. Lewis N, Weston R, Burton J, Young J, Jayakody N, Mastroianni A, et al. *The Family Matters report*. 2019.
19. The Healing Foundation. *Growing Our Children Up Strong And Deadly*. 2013.
20. *Closing the gap*. *National agreement on closing the gap*. 2020. https://www.closingthegap.gov.au/sites/default/files/2021-03/national-agreement-ctg-mar-21_0.pdf.
21. O'Donnell M, Nassar N, Leonard H, Jacoby P, Mathews R, Patterson Y, et al. Characteristics of non-Aboriginal and Aboriginal children and families with substantiated child maltreatment: a population-based study. *Int J Epidemiol* 2010 Jun;**39**(3):921–8.
22. Orr C, Fisher C, Sims S, Preen D, Glauert R, O'Donnell M. Hospitalisations for maternal assault are associated with increased risk of child protection involvement. *Child Abuse Neglect* 2019;**95**:104014. http://www.sciencedirect.com/science/article/pii/S0145213419301759.
23. Segal L, Nguyen H, Mansor M, Gnanamanickam E, Doidge J, Preen D, et al. Lifetime risk of child protection system involvement in South Australia for Aboriginal and non-Aboriginal children, 1986– 2017 using linked administrative data. *Child Abuse Neglect* 2019;**97**:104145. http://www.sciencedirect.com/science/article/pii/S0145213419303229.
24. Eades S. *I CaRe WA - Indigenous Child Removals WA [Internet]*. 2024. https://mspgh.unimelb.edu.au/research-groups/centre-for-epidemiology-and-biostatistics research/indigenous-epidemiology-and-health/i-care-wa-indigenous-child-removals-wa.
25. Moodie S, Jones J, Chenhall R, Williams R, Garlett C, Gibberd A, et al. Intersectoral collaboration for supporting the health and wellbeing of Aboriginal families and children in out-of-home care: perspectives from Western Australian Aboriginal Community Controlled Health Organisations. *Front Public Health* 2024;**12**:1392208.
26. Harrap B, Gibberd A, O'Donnell M, Jones J, Chenhall R, McNamara B, et al. Mental and neurodevelopmental health needs of Aboriginal children with experience of out-of-home care: a Western Australian data-linkage study. *Aust N Z J Publ Health* 2024 Oct 1;**48**(5):100181.
27. Holman CDJ, Bass JA, Rosman DL, Smith MB, Semmens JB, Glasson EJ, et al. A decade of data linkage in Western Australia: strategic design, applications and benefits of the WA data linkage system. *Aust Health Rev* 2008;**32**(4):766–77.
28. R Core Team. *R: a language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing; 2024. https://www.R-project.org/.
29. RStudio Team. *RStudio: integrated development environment for r. Boston, MA: RStudio, PBC*. 2020. http://www.rstudio.com/.
30. Ho DE, Imai K, King G, Stuart EA. MatchIt: nonparametric preprocessing for parametric causal inference. *J Stat Software* 2011;**42**(8):1–28.
31. Australian Bureau of Statistics. *Australian statistical geography standard (ASGS): volume 5–remoteness structure*. Canberra: Australian Bureau of Statistics; 2016. https://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/1270.0.55.005Main%20Features10July%202016.
32. Australian Bureau of Statistics. *Technical paper: socio-economic indexes for areas (SEIFA)*. Canberra: Commonwealth of Australia; 2016. https://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/756EE3DBEFA869EFCA258259000BA746/$File/SEIFA%202016%20Technical%20Paper.pdf.
33. Hansen BB, Klopfer SO. Optimal full matching and related designs via network flows. *J Comput Graph Stat* 2006;**15**(3):609–27. https://doi.org/10.1198/106186006X137047.
34. Fathima P, Jones MA, Moore HC, Blyth CC, Gibbs RA, Snelling TL. Impact of rotavirus vaccines on gastroenteritis hospitalizations in Western Australia: a time-series analysis. *J Epidemiol* 2021;**31**(8):480–6.
35. Australian Institute of Health and Welfare. *Australia's children*. Canberra: AIHW; 2022. Australian Government, https://www.aihw.gov.au/reports/children-youth/australias-children.
36. Stevenson M, Sergeant E, Firestone S. *epiR: tools for the analysis of epidemiological data*. https://CRAN.R-project.org/package=epiR; 2024.
37. Brooks ME, Kristensen K, van Benthem KJ, Magnusson A, Berg CW, Nielsen A, et al. glmmTMB balances speed and flexibility among packages for zero-inflated generalized linear mixed modeling. *The R Journal* 2017;**9**(2):378–400.
38. Kipruto E, Kammer M, Royston P, Sauerbrei W. *mfp2: multivariable fractional polynomial models with extensions*. https://CRAN.R-project.org/package=mfp2; 2023.
39. Gnanamanickam ES, Nguyen H, Armfield JM, Doidge JC, Brown DS, Preen DB, et al. Hospitalizations among children involved in the child protection system: a long-term birth cohort study from infancy to adulthood using administrative data. *Child Abuse Neglect* 2020;**107**:104518. Available from: https://www.sciencedirect.com/science/article/pii/S0145213420301733.
40. Harrap B, Gibberd A, O'Donnell M, Simons K, Jones J, Lima F, et al. Cumulative incidence of child protection system contacts among a cohort of Western Australian Aboriginal children born 2000 to 2013. *Child Abuse Neglect* 2023 Sep 1;**143**:106297.
41. Raman S, Ruston S, Irwin S, Tran P, Hotton P, Thorne S. Taking culture seriously: can we improve the developmental health and well-being of Australian Aboriginal children in out-of-home care? *Child Care Health Dev* 2017;**43**(6):899–905. https://onlinelibrary.wiley.com/doi/abs/10.1111/cch.12488.
42. Shmerling E, Creati M, Belfrage M, Hedges S. The health needs of Aboriginal and Torres Strait Islander children in out-of-home care. *J Paediatr Child Health* 2020;**56**(3):384–8. https://onlinelibrary.wiley.com/doi/abs/10.1111/jpc.14624.
43. Lima F, O'Donnell M, Gibberd AJ, Falster K, Banks E, Jones J, et al. Aboriginal children placed in out-of-home care: pathways through the child protection system. *Aust Soc Work* 2024:1–15.
44. Select Committee into Child Development Services. *Child development services in Western Australia: valuing our children and their needs interim report*. https://www.parliament.wa.gov.au/Parliament/commit.nsf/(Report+Lookup+by+Com+ID)/D74B867E4E794A5548258A75001ABC49/$file/CDS+Interim+Report.pdf; 2023.
45. Kairuz CA, Casanelia LM, Bennett-Brook K, Coombes J, Yadav UN. Impact of racism and discrimination on physical and mental health among Aboriginal and Torres Strait islander peoples living in Australia: a systematic scoping review. *BMC Public Health* 2021 Dec;**21**:1–6.
46. Wilkes B, Colonna E, Thurber K, Lovett R. 'Health impacts of racism' in national aboriginal community controlled health organisation and the Royal Australian College of general practitioners. In: *National guide to preventive healthcare for Aboriginal and Torres Strait Islander people: Recommendations*. 4th Edition; 2024. p. 39–46.
47. Department of Communities. *Casework Practice Manual: 3412 health care planning*. https://www.wa.gov.au/organisation/department-of-communities/casework-practice-manual#article/3412-health-care-planning; 2024.
48. Government of Western Australia. *Health navigator pilot program*. https://www.fcawa.com.au/wp-content/uploads/2023/03/Health-Navigator-Pilot-Program.pdf; 2023.
49. Government of Western Australia. *New program launched to support the health of vulnerable children*. https://web.archive.org/web/20230327040534/https://www.mediastatements.wa.gov.au/Pages/McGowan/2022/12/New-program-launched-to-support-the-health-of-vulnerable-children.aspx; 2022.
50. Evershed N, May N. Australia lost hundreds of fully subsidised GP clinics in the past year – how does your area rank? *Guardian* 2024 Feb 22. https://www.theguardian.com/australia-news/2024/feb/22/bulk-billing-gp-doctors-australia-list-map-tracker-states-nsw-act-qld-vic-wa.
51. Office of the Auditor General Western Australia. *Management of long stay patients in public hospitals*. https://audit.wa.gov.au/wp-content/uploads/2022/11/Report-9_Management-of-Long-Stay-Patients-in-Public-Hospitals.pdf; 2022.
52. Dalton A, Carter R. *Economic evaluation of the Indigenous Australians' health programme phase I*. Deakin University Health Economics Centre for Population Health Research; 2018.

Appendix A Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.anzjph.2025.100249.