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Evaluating the “right@home” randomized trial of nurse home visiting using linked administrative data at school transition

Anna Price^{1,2,3,*}, Jiaxin Zhang^{3,4}, Sharon Goldfeld^{1,2,3}, John Carlin^{3,4}, and Fiona Mensah^{2,3}

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¹Centre for Community Child Health, The Royal Children's Hospital, Parkville, VIC 3052, Australia

²Population Health, Murdoch Children's Research Institute, Parkville, VIC 3052, Australia

³Department of Paediatrics, University of Melbourne, Parkville, VIC 3052, Australia

⁴Clinical Epidemiology and Biostatistics Unit, Murdoch Children's Research Institute, The Royal Children's Hospital, Parkville, VIC 3052, Australia

Abstract

Introduction

Nurse home visiting (NHV) is designed to redress child and maternal health inequities, but long-term evaluation is hampered by sample attrition. Evaluation using administrative data has the potential to overcome attrition through provision of a more complete outcome profile. Australia's “right@home” trial is the only long-running evaluation of NHV designed for a population with universal healthcare.

Objectives

To investigate the effects of the NHV program on children's health and development outcomes and service use, compared with usual care (comparator), using linked administrative data at school transition.

Methods

A screening survey identified pregnant women experiencing adversity from antenatal clinics across two states (Victoria, Tasmania). 722 were randomized: 363 to the right@home program (25 visits promoting parenting and home learning environment) and 359 to usual care. At children's first birthdays, 198/237 (83.5%) Tasmanian and 420/485 (86.6%) Victorian parents consented to data linkage with the Tasmanian Kindergarten Development Check (KDC, 4 years) and Victorian School Entrant Health Questionnaire (SEHQ, 5-6 years), respectively. Jurisdictional differences meant measures could not be harmonized, and variables varied in their interpretability. Following best-practice methods for managing missing data, outcomes were compared between groups (intention-to-treat) using regression models adjusted for stratification factors, baseline variables, and nurse/site cluster.

Results

Linked data were obtained for $n = 134/237$ (56.5%) Tasmanian and $n = 252/485$ (52.0%) Victorian children. These children had substantially higher prevalence of negative life events and poorer health and development outcomes, and used similar or more services than children state-wide. Compared with usual care, the NHV program increased KDC achievement and SEHQ health service use. There was less evidence for program impacts on SEHQ outcomes.

Conclusions

Benefits of NHV were evident at school transition for child development outcomes and service use. This adds further evidence for NHV being an important component of universal health services that deliver support responsive to families' needs.

Registration

ISRCTN89962120

Keywords

child development; child health; disadvantage; linked administrative data; nurse home visiting; randomized controlled trial; school transition

*Corresponding Author:

Email Address: anna.price@mcri.edu.au (Anna Price)

Introduction

The first 1000 days of life from conception to 2 years lay the foundation for ongoing health and development [1]. Socioeconomic adversity in the family environment (commonly termed disadvantage), such as poor parental mental health and poverty, can diminish women's and children's lifelong opportunities, spanning cognitive development, educational attainment, employment, and societal participation [1–3]. Nurse home visiting (NHV) is a model of service delivery that supports women experiencing adversity to overcome common barriers to service access [4]. NHV provides intensive and sustained support from a nurse in the home from pregnancy or a child's birth until children typically turn two years old [4, 5]. Overcoming barriers to service access and providing effective interventions in the home is important because morbidity and mortality increase as adversity increases, yet access to timely, high-quality interventions decreases [6, 7]. This phenomenon is known as the inverse care law [5]. NHV is one of the few public health programs with evidence for benefits to maternal and child outcomes and reductions in inequities [8]. However, long-term follow-up of NHV programs is challenging due to the resource-intensive nature of engaging and retaining families experiencing adversity, and the effects that attrition has on representativeness and statistical precision [9, 10]. Linkage with administrative data has the potential to overcome these challenges by enabling a more complete outcome profile.

Almost all previous randomized controlled trials (RCTs) of NHV programs have ended follow-up by the time children turn 3 years old [11]. This is problematic because benefits of NHV for children become increasingly evident as children grow older, requiring long-term follow-up [12, 13]. Of six trials to evaluate NHV programs to school entry age (5–7 years), Australia's "right@home" program is the only one designed for a high-income country with universal healthcare [4, 12, 14]. Annual follow-up with participating women and children since completing program delivery at 2 years has demonstrated program benefits across domains including parenting, the home environment, maternal mental health and wellbeing from 2–6 years, and benefits to children's behavior at 5–6 years, and their learning, reading, and social skills at 6 years [12, 15–17]. The other five long-running RCTs of NHV trialed Nurse Family Partnership (NFP) or an adaptation of it, which was designed for young and single women in the United States (US). Three trials were evaluated by the model developer in the US; one was tested in the United Kingdom (UK; "Building Blocks") [18]; and one was adapted to Germany's health system with delivery by midwives ("Pro Kind") [12, 19]. Despite differences in content, dose, populations, and settings, the trials have reported benefits across domains including children's learning and behavior, although specific effects are mixed between studies [12].

When the Australian right@home protocol was originally developed and funded in 2012, the trial's primary endpoint was specified at the children's second birthdays [14]. To overcome the limitations of this short-term follow-up, at the 1-year-old follow-up wave, participating women were invited to consent to future data linkage with their child's school transition data. Administrative data are an important resource for research, yet may have limited usefulness since neither the data nor their collection are usually designed for research

purposes [20]. Improving the quality of administrative data research is also difficult because the challenges are rarely published [20]. Of the long-running NHV RCTs, only the UK Building Blocks trial was evaluated using administrative data (the other published trials collected data directly), and the authors found no evidence of effects on the primary outcome of child maltreatment [18]. There were secondary benefits to school readiness and reading, but not school attendance, or science or mathematics levels. In instances such as this, where the program was not originally designed for the population, and the data collection was not designed for the research, it is challenging to distinguish potential program effects from the design elements [20, 21].

In Australia, right@home was designed to improve the learning and development of children raised in adversity by school entry, and delivered and tested across two states, Tasmania and Victoria [4, 14]. In Tasmania, the Kindergarten Development Check (KDC) is completed by educators for every child in government-funded kindergartens in the year before school entry (age 4 years; note, kindergarten is preschool education). The KDC comprises 21 items across five domains: speech, language, listening and speaking, cognitive development, personal and social behavior, gross motor, and fine motor. In Victoria, the School Entrant Health Questionnaire (SEHQ) [22] is sent home with all children in the first year of school ("Grade Prep", ages 5–6 years) for completion by a caregiver, and returned for scoring by school nurses. The SEHQ comprises five sections with questions covering health, speech and language, behavior and emotional wellbeing (collectively termed "health and development" throughout) plus service use, and family issues and stressors. The KDC and SEHQ differ in terms of child age, respondents, and measures. However, the domains (except the SEHQ family issues and stressors) broadly align with the outcomes specified by the right@home program logic [14, 21]. As such, we aimed to use the linked administrative data to investigate the effects of the right@home NHV program compared with usual care on children's health and development outcomes and service use at the period of transition to primary education.

Methods

Design and setting

RCT of a NHV program delivered from pregnancy to children's second birthdays, embedded in and compared with Australia's existing universal Child and Family Health Nursing services (usual care). Published protocol <https://doi.org/10.1136/bmjopen-2016-013307> [14]. This paper presents analysis of linked administrative data obtained in 2019–22, reported according to the Consolidated Standards of Reporting Trials (CONSORT) statement.

Participants

Researchers recruited pregnant women attending antenatal clinics of 10 public maternity hospitals across Tasmania and Victoria, 30 April 2013 to 29 August 2014. Both states are multicultural and seek to provide healthcare and health promotion with culturally and linguistically diverse

families including Aboriginal and Torres Strait Islander communities [23, 24]. Trial enrolment was offered to all eligible and consenting women. The trial did not recruit participants according to cultural background nor was able to modify the provision of the program at this stage. Eligible women: (i) had due dates before 1 October 2014, (ii) were less than 37 weeks gestation, (iii) had sufficient English for face-to-face interviews, (iv) lived within travel boundaries specified by participating areas; and (v) had 2 or more of 10 risk factors identified at screening (young woman during pregnancy; not living with another adult; no support in pregnancy; poor health; a long-term illness, health problem, or disability that limits daily activities; currently smokes; stress, anxiety or difficulty coping; low education; no person in the household currently earning an income; and never having had a job before). Women were excluded if they: (i) were enrolled in an existing Tasmanian NHV program for 15-19-year-olds, (ii) did not comprehend the recruitment invitation (e.g., intellectual disability), (iii) had no mechanism for contact, or (iv) experienced a critical event (e.g., termination of pregnancy, stillbirth, child death).

Procedure and consent

Following screening, eligible women provided informed consent and completed a home-based baseline interview. Women were randomized to control or intervention groups with a 1:1 allocation following a computer-generated schedule stratified by site and parity (first-time parent). Managerial staff, participants and intervention teams were aware of allocation. Researchers who conducted annual follow-ups were blinded to randomization. At the 1-year interview, the 637/722 (88.2%) participating parents were invited to consent to future data linkage with their child's school transition data. Figure 1 shows that when the linked data were requested from the state education departments, $n = 198/237$ (83.5%) Tasmanian and $n = 420/485$ (86.6%) Victorian children had consent for linkage and women had not withdrawn from the original cohort of $n = 722$.

Program development

Conducted in partnership with the Tasmanian and Victorian state governments, the right@home NHV program was developed from reviews of the evidence for factors that promote children's neurodevelopment, effective interventions for home-based parenting programs, and processes for working with families experiencing adversity [4]. The resulting intervention was structured using the Maternal Early Childhood Sustained Home-visiting (MECSH) framework and training [25], augmented by five evidence-based strategies for content (infant/child sleep, safety, nutrition, regulation, bonding/relationship) and two delivery approaches (video feedback and motivational interviewing) [4, 14]. When the intervention ended, nurses supported families to connect with the local community-based services. Implementation was enabled using detailed fidelity monitoring [26]. An Expert Reference Group incorporated stakeholders and experts to advise on the design, implementation, and interpretation of the trial; no formal data monitoring committee was implemented. The trial is registered at ISRCTN89962120 (status: complete).

Funding was obtained to extend direct follow-up (annual interviews and assessments) until child age 6 years and are previously published [12, 15–17].

Intervention delivery

Women randomized to the intervention group were offered 25 nurse home visits (mean 23.2 home visits [SD 7.4] received), commencing antenatally and delivered mostly by the same nurse (of 18) trained in the right@home NHV model [17, 26]. Nurses were Child and Family Health Nurses who, during the period of implementation, required nursing and midwifery qualifications. Most intervention women (75.6%) also received one or more home visits by a social care practitioner (mean 1.7, range 0-15), who provided case management as needed (e.g. connecting families to services such as emergency relief and legal aid) [17, 26].

Usual Child and Family Health service (comparator)

Women in the control group received up to six (Tasmania) or nine (Victoria) free consultations to age 2 years (mean 7.6 consultations [SD 4.3] received) [17]. After an initial home visit, subsequent appointments were conducted in local clinics. The Victorian service also included flexibility to offer additional home-based appointments in the first year postpartum depending on family need.

Measures and procedure

The items and scoring for the Tasmanian Kindergarten Development Check (KDC) [27] and Victorian School Entrant Health Questionnaire (SEHQ) [28] are described in Supplementary Table 1. The KDC was developed for the Tasmanian Government in 1994 to identify Kindergarten students who were not achieving expected development outcomes. Subsequent revisions over time were made in line with the state government's curriculum framework, although the item sources were not specified. The version completed by educators for children in the current study comprised 21 items across five sub-domains [27]. The publicly available KDC information states: "*The Check provides information to support teachers' educational planning and referral to allied health professionals when required*" [29].

The Victorian SEHQ has been distributed since 1997, and also undergone revisions over time. The publicly available information states: "*The SEHQ is an annual survey that records parents' concerns and observations about their child's health and wellbeing during their child's first year at school. The questionnaire is completed by parents and guardians of Prep children in Victorian primary schools through the Victorian Primary School Nursing Program across the year. The information collected in the SEHQ is a starting point for nurses to carry out further assessment of the child and family and determine appropriate intervention and/or referral as required. Analysis of the SEHQ data is also used to inform planning and service delivery*" [22]. In the version completed by caregivers of children in this study, the Strengths and Difficulties Questionnaire (SDQ) and the Parental Evaluation of Development Status (PEDS) were

included as measures children's behavior, emotional wellbeing, health and development (Supplementary Table 1). Children's speech and language, health service use, and family issues and stressors, were assessed with a range of categorical items that were originally selected through literature reviews, piloting and revision, although the sources were not specified [28].

Data linkage

The procedures for obtaining linked data were similar between jurisdictions. They involved completing online applications to the state education departments for access to the data, which, once approved, were followed by securely sharing copies of the participant consent forms and a summary of identifying data (name, date of birth, school if known). The education departments then identified and provided the participating student data. Consistent with the literature on using population data linkage for research, the methods for data capture, processing and linkage were opaque [20]. In correspondence with the departments, the lead author learned that this was likely because many individuals and departments are responsible for the many steps (e.g. survey distribution, collection, scoring, data entry, cleaning, linkage) and information is not always available or shared between them.

The Tasmanian children in right@home turned four years old and began kindergarten in 2018–20. The Victorian children in right@home turned five years old and began school in 2019–21. Both departments publish annual reports summarizing the measures [22, 29]. The published data (termed “state-wide” throughout) are presented from 2020 for comparison as this was the closest year with data available. The Tasmanian KDC was intended for completion by educators of the 70% of students enrolled in a government kindergarten program; however, neither the denominators nor numerators are published. The Victorian SEHQ was completed by $n = 53,967$ (66%) of eligible enrolments in 2020, which was a lower response fraction than earlier years (around 80%) due to the COVID-19 pandemic. Demographics and outcomes of responding parents were similar across the years. Neither state's descriptive data were weighted to approximate population characteristics and data on representativeness were not published.

Given the complex nature of the right@home NHV intervention, multifactorial outcomes are required to evaluate the program across the breadth of intended effects [30]. To comprehensively evaluate the balance of evidence for treatment effects, we examined the direction and magnitude of estimated effects, including uncertainty and variability, for the multiple health and development and health service outcomes [31]. This approach follows the rationale for our previous stages of the trial evaluation [12, 15–17]. The KDC and SEHQ cannot be harmonized so they were analyzed and reported separately.

Statistical analyses

Sample size

The initial RCT sample size was calculated to detect a minimum effect size of 0.3 SDs in the continuous parent

responsivity outcome at 2 years [14]. A target sample size of 714 participants was estimated to provide 80% power, with 5% significance level, accounting for clustering by nurse provider, and 40% attrition. A final sample size of 722 participants was achieved.

Descriptive analysis

Frequencies and proportions were used to describe baseline characteristics between trial groups by retention (data linked versus lost to follow-up), and to compare the right@home usual care cohort with state-wide proportions for the Tasmanian KDC and Victorian SEHQ in 2020. These comparisons were undertaken to understand whether, consistent with the literature, children born to women experiencing adversity during pregnancy would experience more negative life events and poorer outcomes in early childhood.

Primary analyses

Following best practice and consistent with previous stages of the trial evaluation [12, 32], inverse probability weighting was used to address missing data for the Tasmanian cohort (for which the data that were linked was complete), and multiple imputation and inverse probability weighting were used to address missing data for the Victorian cohort (for which linked data included item level missing data), with the aim of estimating intention-to-treat effects [33]. Details are provided in the Supplementary Material. Treatment effects were estimated as odds ratios (OR) using logistic regression methods. Multivariable models were used to adjust for stratification factors used during randomization (parity, site) and baseline covariates: child gender, family Socio-Economic Index for Areas (SEIFA) score of neighborhood-level disadvantage [34], maternal age, education antenatal risk count (2 or more of 10 factors), self-efficacy and mental health at baseline. Maternal language other than English was also included for child language outcomes. All regression analyses accounted for effects of nurse clustering using robust variance estimation. Summary plots are presented to illustrate the estimated treatment benefits across the range of outcomes [35]. Data were analyzed using R version 4.2.1.

Secondary/sensitivity analyses

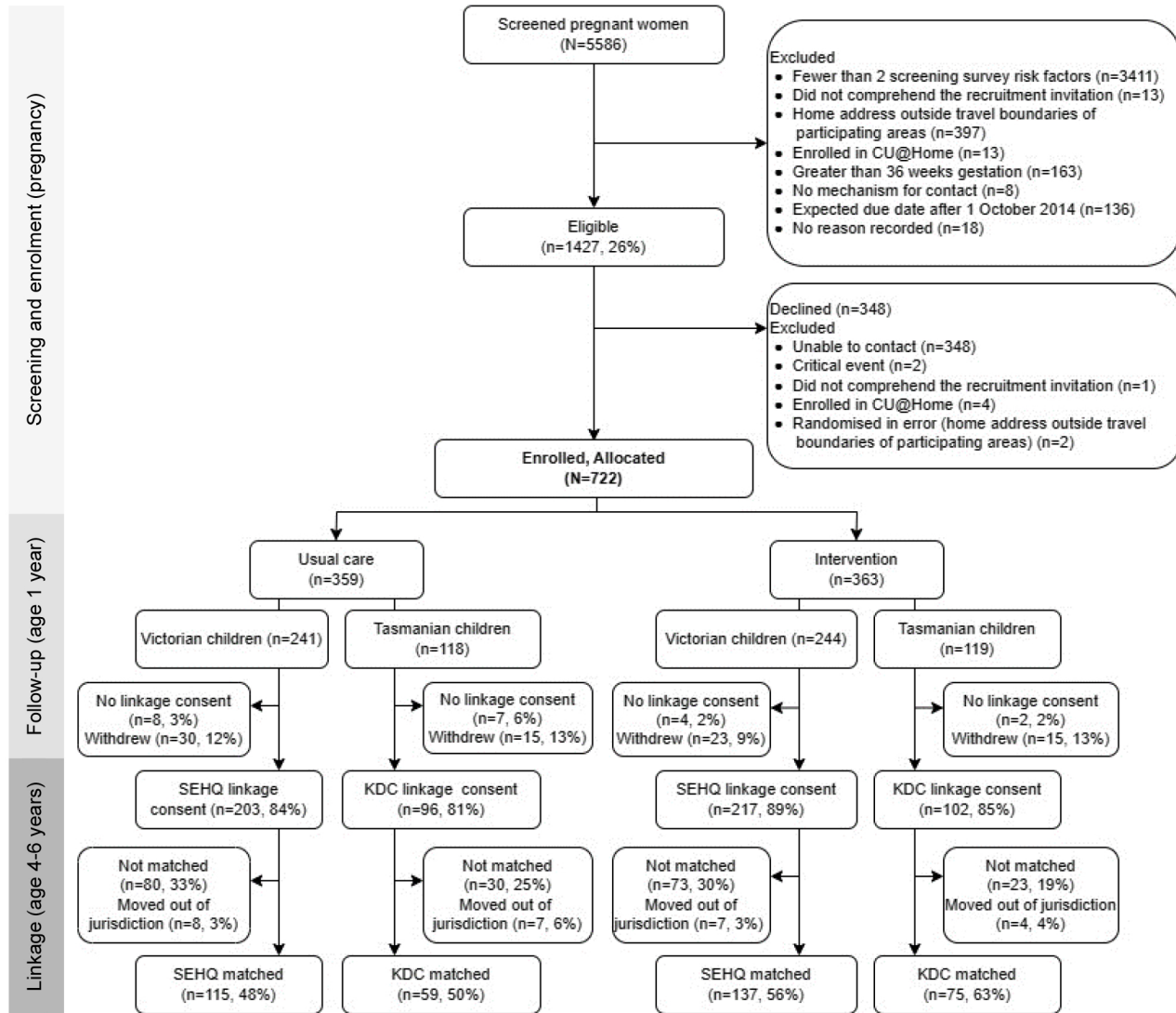
Available case analyses, where all participant data for a given outcome are available, were conducted to evaluate the sensitivity of the findings to sample attrition and missing data.

Results

Participant characteristics

Figure 1 presents the participant flow (CONSORT). Of the 722 women enrolled in the right@home trial, data were successfully linked (matched) for $n = 134/237$ (56.5%) Tasmanian and $n = 252/485$ (52.0%) Victorian children. Data linkage was not possible if the KDC/SEHQ assessment was not completed, the child was no longer enrolled in an eligible primary school, or the child's name or date of birth did not match study information; however, reasons were not enumerated

Figure 1: Participant flow (CONSORT)



SEHQ: Victorian School Entrant Health Questionnaire. KDC: Tasmanian Kindergarten Development Check. Not matched: Data linkage was not possible if (1) the SEHQ/KDC assessment was not completed, (2) the child was no longer enrolled in a Victorian or Tasmanian primary school, or (3) the child's name and/or date of birth did not match study information; however, these reasons were not enumerated by the education departments.

Note, Victorian communities' experience of the COVID-19 pandemic reduced SEHQ completion rates, which were 66% of eligible enrolments in 2020 compared with an average of around 80% in pre-2020 years, and 75% in 2021; however, the response proportions for the domains were similar between years.

by the education departments. The proportion of women who consented and had matched data was higher for the intervention ($n = 212/363$, 58.4%) than the usual care group ($n = 174/359$, 48.5%). This is likely due to having more contact with the intervention women in the first two years of the trial.

Table 1 presents the enrolment (baseline) characteristics for each trial group, by participating families with linked data and lost to follow-up. More families with either parent born in a non-English-speaking country, or with no more than high school education, were lost to follow-up. At randomization, the usual care group had slightly higher proportions of female babies and 3 or more risk factors at screening, and these differences were evident in the follow-up frequencies. Otherwise, the distributions of participant characteristics by follow-up status and trial group were similar.

Comparison of right@home participants with the state-wide population

Table 2 shows that the usual care cohort (Victorian SEHQ) experienced at least 2.5 times the proportions of parent divorce/separation, serious illness of parent, and parent change of job than the state population, and 3–4 times the proportions of historical adversities including parent substance use or mental illness, parent or child abuse, and other family violence.

Table 3 shows that children in the right@home usual care cohort (Tasmanian KDC) were half as likely to have achieved 20 of the 21 KDC items in kindergarten and one-third as likely to have achieved all 21. Table 4 shows that the right@home usual care cohort (Victorian SEHQ) were approximately 1.5 times more likely to have difficulty putting words together, a voice that sounded unusual, or a stutter

Table 1: Baseline characteristics according to provision of linked data at school transition with number of participants (%) unless stated

Baseline characteristics (pregnancy)	Randomized (N = 722)			Linked data provided (N = 386)		Lost to follow-up (N = 336)	
	Program group	Usual care group	Missing %	Program group	Usual care group	Program group	Usual care group
n	363	359		212	174	151	185
Maternal age (years), mean (SD) ^a	27.46 (6.09)	27.83 (6.37)	0	27.51 (5.89)	28.12 (6.55)	27.40 (6.38)	27.56 (6.19)
Education status			10.5				
Did not complete high school	80 (24.8)	82 (25.3)		46 (24.3)	39 (24.4)	34 (25.6)	43 (26.2)
Completed high school	32 (9.9)	19 (5.9)		14 (7.4)	8 (5.0)	18 (13.5)	11 (6.7)
Completed vocational training	176 (54.7)	188 (58.0)		108 (57.1)	99 (61.9)	68 (51.1)	89 (54.3)
Completed degree or higher	34 (10.6)	35 (10.8)		21 (11.1)	14 (8.8)	13 (9.8)	21 (12.8)
Employed in paid work	124 (34.2)	120 (33.4)	0	72 (34.0)	61 (35.1)	52 (34.4)	59 (31.9)
Partnered	256 (70.5)	260 (72.4)	0	148 (69.8)	123 (70.7)	108 (71.5)	137 (74.1)
Either parent born in a non-English speaking country	81 (22.6)	90 (25.4)	1.1	34 (16.2)	37 (21.4)	47 (31.5)	53 (29.1)
Poor Mental health							
DASS Depression, >85th percentile score	64 (17.6)	57 (15.9)	0	40 (18.9)	20 (11.5)	24 (15.9)	37 (20.0)
DASS Anxiety, >85th percentile score	157 (43.3)	149 (41.5)	0	94 (44.3)	68 (39.1)	63 (41.7)	81 (43.8)
DASS Stress, >85th percentile score	73 (20.1)	68 (18.9)	0	41 (19.3)	29 (16.7)	32 (21.2)	39 (21.1)
Above 85th centile for any DASS subscale	173 (47.7)	164 (45.7)	0	102 (48.1)	73 (42.0)	71 (47.0)	91 (49.2)
AQoL global utility score (mean (SD))	0.64 (0.18)	0.64 (0.18)	0.1	0.63 (0.19)	0.66 (0.17)	0.66 (0.18)	0.63 (0.19)
3 or more risk factors at screening (of 10)	211 (58.1)	236 (65.7)	0	122 (57.5)	115 (66.1)	89 (58.9)	121 (65.4)
Self-reported general health		1.4					
Poor	10 (2.8)	10 (2.8)		7 (3.3)	2 (1.2)	3 (2.0)	8 (4.4)
Fair	44 (12.2)	51 (14.5)		27 (12.9)	17 (9.9)	17 (11.3)	34 (18.8)
Good	151 (41.9)	136 (38.6)		92 (43.8)	67 (39.2)	59 (39.3)	69 (38.1)
Very good	118 (32.8)	119 (33.8)		64 (30.5)	66 (38.6)	54 (36.0)	53 (29.3)
Excellent	37 (10.3)	36 (10.2)		20 (9.5)	19 (11.1)	17 (11.3)	17 (9.4)
Smokes	119 (32.8)	118 (32.9)	0	73 (34.4)	54 (31.0)	46 (30.5)	64 (34.6)
Parity: second child or more	228 (62.8)	228 (63.5)	0	130 (61.3)	113 (64.9)	98 (64.9)	115 (62.2)
Baby's sex: female	191 (54.4)	154 (44.6)	3.6	120 (56.6)	84 (48.3)	71 (51.1)	70 (40.9)
Self-efficacy ^b	244 (67.6)	247 (68.8)	0.3	142 (67.3)	120 (69.0)	102 (68.0)	127 (68.6)
SEIFA Index of Social Disadvantage Score	947.95 (62.84)	952.40 (66.34)	3.2	945.97 (62.59)	951.10 (64.47)	950.81 (63.30)	953.63 (68.22)
Language other than English spoken at home	33 (9.1)	40 (11.2)	0.3	17 (8.0)	16 (9.2)	16 (10.6)	24 (13.0)
Household main source of income		0					
Full time employment	166 (45.7)	168 (46.8)		100 (47.2)	79 (45.4)	66 (43.7)	89 (48.1)
Part time employment	29 (8.0)	34 (9.5)		13 (6.1)	16 (9.2)	16 (10.6)	18 (9.7)
Benefit/Pension	159 (43.8)	150 (41.8)		93 (43.9)	75 (43.1)	66 (43.7)	75 (40.5)
Other	9 (2.5)	7 (1.9)		6 (2.8)	4 (2.3)	3 (2.0)	3 (1.6)
Household type of accommodation		0.3					
Fully owned	11 (3.0)	18 (5.0)		6 (2.8)	8 (4.6)	5 (3.3)	10 (5.4)
Being purchased	86 (23.8)	83 (23.2)		56 (26.5)	38 (22.0)	30 (19.9)	45 (24.3)
Rent public	92 (25.4)	92 (25.7)		49 (23.2)	46 (26.6)	43 (28.5)	46 (24.9)
Rent private	161 (44.5)	157 (43.9)		95 (45.0)	76 (43.9)	66 (43.7)	81 (43.8)
Other	12 (3.3)	8 (2.2)		5 (2.4)	5 (2.9)	7 (4.6)	3 (1.6)
Having housing problems	58 (16.7)	62 (18.0)	4.3	35 (17.2)	32 (19.4)	23 (16.0)	30 (16.8)
Being threatened with eviction	10 (2.9)	8 (2.3)	4.3	6 (3.0)	4 (2.4)	4 (2.8)	4 (2.2)

AQoL: Assessment Quality of Life; DASS: Depression, Anxiety, Stress Scale; NHV: Nurse home visiting; SD: Standard Deviation; SEIFA: Socioeconomic Indexes for Areas (national mean of 1000, higher scores indicate greater advantage).

^aOutcome is continuous (mean, SD).

^b3 items assessing mother's self-efficacy, drawn from the UK Millennium Cohort.³⁶ Each item reflected the presence versus absence of self-efficacy and were used to form a single dichotomous item reflecting 'any lack of self-efficacy' versus 'no lack of self-efficacy'.

Table 2: Proportions children experiencing family issues and stressors (Victoria), state-wide in 2020, and for the right@home Usual Care group, using multiply imputed data

Victoria school entrant health Questionnaire (SEHQ) family issues and stressors	2020 State-wide comparison	right@home usual care group
	% (n/53,967) ^a	Estimated % (n/241)
Child affected by:		
divorce/separated parents	4.2	25.4
death of relative/friend	6.9	18.4
remarriage of parent	1.5	12.3
serious illness of parent	2.5	10.5
serious illness of sibling	1.1	13.2
parent change of job	4.1	17.5
parent loss of job	1.7	10.5
move to new house	6.4	16.7
new baby in home	3.8	15.8
History of:		
alcohol or drug related problems in family	3.6	16.7
abuse to parent	5.4	23.7
abuse to child	1.9	12.3
child witnessing violence	3.5	19.3
gambling problem in the family	0.6	8.8
mental illness of parent	8.8	25.4

^an for rows not published for state-wide data.

Table 3: Proportions for the state and the right@home trial groups (Tasmania), and adjusted regression analyses comparing the two trial groups on child outcomes, using inverse probability weighted data

Tasmanian kindergarten development check (KDC) items (age 4 years) ^a	Descriptive statistics			Adjusted odds ratio comparing the intervention with the usual care group			
	State-wide comparison	Usual care	r@h NHV intervention	Odds ratio	95% Confidence interval		p-value
	% ^b (2020)	n/118 (%)	n/119 (%)		Lower	Upper	
Achieved 20 indicators	75.9%	21 (36.8)	41 (54.7)	2.32	1.11	4.87	0.03
Achieved all 21 indicators	60.7%	12 (21.1)	27 (36.0)	2.48	0.97	6.34	0.06
Achieved all indicators in each domain:							
Speech, language, listening and speaking	n/a	28 (49.1)	46 (61.3)	1.52	0.55	4.18	0.42
Cognitive development	n/a	21 (36.8)	46 (61.3)	3.30	1.31	8.34	0.01
Personal and social behavior	n/a	44 (75.9)	58 (77.3)	1.48	0.48	4.52	0.50
Gross motor	n/a	25 (43.1)	45 (60.0)	2.33	1.13	4.84	0.02
Fine motor	n/a	46 (79.3)	68 (90.7)	3.58	0.76	16.79	0.11

n/a: state-wide data not available. Summary statistics exclude missing data. Inverse probability weighting was used to address missing data for the Tasmanian cohort. Models were adjusted for stratification factors used during randomization (parity, site) and baseline covariates: child gender, family Socio-Economic Index for Areas (SEIFA) score of neighborhood-level disadvantage, maternal age, education antenatal risk count (2 or more of 10 factors), self-efficacy and mental health at baseline. Maternal language other than English was also included for child language outcomes. All regression analyses accounted for effects of nurse clustering using robust estimation.

^aChild scored 'yes' (achieving) to all items in Tasmanian Kindergarten Development Check (KDC) domain items.

^bDenominator and numerator not available. Note, the 2020 KDC outcome was impacted by COVID-19, as only one assessment was conducted. As a result, comparisons with 2021 and previous years should be exercised with caution. In 2019, 67.8% of the measured cohort achieved all 21 indicators.

Table 4: Proportions for the state and the right@home trial groups (Victoria), and adjusted regression analyses comparing the two trial groups on child outcomes, using multiply imputed and inverse probability weighted data

Victoria school entrant Health questionnaire (SEHQ) (age 5-6 years)	Descriptive statistics			Adjusted odds ratio comparing the intervention with the usual care group			
	State-wide comparison	Usual Care	r@h NHV Intervention	Odds ratio	95% Confidence interval Lower Upper	p-value	
Speech and language	n/53,967 (%)	Estimated %	Estimated %				
Child has difficulties with speech or language (any)	8,645 (16.0)	17.5	22.6	1.71	1.15	2.55	0.01
unclear to others	6,495 (12.0)	12.3	19.7	2.18	1.39	3.45	0.00
difficulty putting words together	3,271 (6.1)	9.6	6.6	0.82	0.45	1.50	0.52
voice sounds unusual	1,273 (2.4)	4.4	2.2	0.58	0.16	2.03	0.39
stutters or stammers	2,246 (4.2)	7.9	7.3	0.92	0.54	1.58	0.77
Behavior and emotional wellbeing							
SDQ Total difficulties: moderate or high risk	11,969 (22.2)	26.3	29.2	1.10	0.72	1.67	0.66
SDQ Emotional problems: moderate or high risk	7,144 (13.2)	43.9	38.7	0.82	0.44	1.51	0.52
SDQ Conduct problems: moderate or high risk	11,969 (22.2)	27.2	28.5	1.01	0.59	1.74	0.98
SDQ Hyperactivity: moderate or high risk	7,951 (14.7)	31.6	32.8	1.16	0.79	1.70	0.44
SDQ Peer problems: moderate or high risk	9,848 (18.2)	15.8	14.6	1.02	0.72	1.47	0.90
SDQ Prosocial problems: moderate or high risk	4,151 (7.7)	28.9	27.0	0.92	0.51	1.66	0.78
Child health and development							
PEDS Parent concerned about child's:							
oral health	8,754 (16.2)	20.2	20.4	1.03	0.78	1.36	0.84
eyesight	4,531 (8.4)	18.4	13.9	0.77	0.46	1.29	0.32
learning, development and behavior	n/a	49.1	36.5	0.61	0.47	0.80	0.00
talking and making speech sounds	n/a	29.8	27.7	1.06	0.77	1.44	0.73
understanding of what parent says	n/a	10.5	12.4	1.36	0.63	2.92	0.43
use of hands and fingers to do things	n/a	12.3	10.2	0.90	0.47	1.74	0.76
use of arms and legs	n/a	7.0	8.8	1.70	0.59	4.90	0.33
behavior	n/a	28.9	27.0	0.96	0.56	1.66	0.89
getting along with others	n/a	16.7	22.6	2.07	0.88	4.84	0.09
learning to do things for themselves	n/a	11.4	7.3	0.84	0.42	1.70	0.64
learning preschool or school skills	n/a	14.0	10.9	0.88	0.51	1.50	0.63
intellectual disability, development delay or learning disability	n/a	18.4	12.4	0.70	0.33	1.46	0.34

PEDS: Parental Evaluation of Development Status; r@h NHV: right@home Nurse Home Visiting. SDQ: Strengths and Difficulties Questionnaire. n/a: state-wide data not available.

Subscale scoring (SDQ, PEDS) was completed by school nurses and subscale scores were not available for linkage.

Multiple imputation and inverse probability weighting were used to address missing data for the Victorian cohort. Models were adjusted for stratification factors used during randomization (parity, site) and baseline covariates: child gender, family Socio-Economic Index for Areas (SEIFA) score of neighborhood-level disadvantage, maternal age, education antenatal risk count (2 or more of 10 factors), self-efficacy and mental health at baseline. Maternal language other than English was also included for child language outcomes. All regression analyses accounted for effects of nurse clustering using robust estimation.

or stammer, compared with the state-wide proportions, but otherwise had similar proportions for being unclear or any speech or language difficulties. Except for the SDQ prosocial subscale, the proportions of moderate or high problems for the right@home cohort (Victorian SEHQ) were higher for

the SDQ scores, notably for the emotional, hyperactivity and prosocial subscales, which were two-to-three times those of the state.

Table 5 shows that, compared with the state, more children in the right@home usual care cohort (Victorian SEHQ) were

Table 5: Proportions for the state and the right@home trial groups (Victoria), and adjusted regression analysis comparing the trial groups on child health service use, using multiply imputed and inverse probability weighted data

Victoria school entrant health questionnaire (SEHQ) (age 5-6 years)	Descriptive statistics			Adjusted odds ratio comparing the intervention with the usual care group			
	State-wide comparison	Usual care	r@h NHV intervention	Odds ratio	95% Confidence interval Lower	Upper	p-value
Speech and language	n/53,967 (%)	Estimated %	Estimated %				
Child diagnosed with asthma	5,502 (10.2)	21.1	23.4	0.96	0.64	1.45	0.84
Child diagnosed with allergy	4,614 (8.6)	9.6	15.3	2.00	1.08	3.72	0.03
Child attended:							
maternal and child health preschool check	38,073 (70.5)	87.7	92.0	1.41	0.99	2.02	0.06
early childhood intervention service	2,786 (5.2)	7.0	8.0	1.36	0.75	2.49	0.31
dentist (including orthodontist, periodontist etc)	26,932 (49.9)	47.4	55.5	1.69	1.24	2.30	0.00
paediatrician	6,638 (12.3)	14.0	14.6	1.43	0.92	2.22	0.12
optometrist/eye doctor	8,753 (16.2)	23.7	24.1	0.91	0.49	1.67	0.76
audiologist/hearing specialist	4,113 (7.6)	10.5	12.4	1.24	0.58	2.64	0.58
speech pathologist/speech therapist	6,071 (11.2)	16.7	20.4	1.75	1.10	2.79	0.02
early learning center or kindergarten	46,788 (86.7)	93.0	91.2	0.75	0.34	1.66	0.47

Multiple imputation and inverse probability weighting were used to address missing data for the Victorian cohort. Models were adjusted for stratification factors used during randomization (parity, site) and baseline covariates: child gender, family Socio-Economic Index for Areas (SEIFA) score of neighborhood-level disadvantage, maternal age, education antenatal risk count (2 or more of 10 factors), self-efficacy and mental health at baseline. All regression analyses accounted for effects of nurse clustering using robust estimation.

diagnosed with asthma, and visited maternal and child health nurses, an optometrist, speech pathologist or early learning center. Proportions for allergy diagnoses and other health service use were similar.

Effects of the right@home NHV program (Aim 2)

Table 3 and Figure 2 present the KDC outcomes for Tasmanian children. The estimated ORs for the five sub-domains indicated that more children in the intervention group had achieved the development milestones than children in the usual care group. The estimated group differences for achieving 20 or 21 of the 21 indicators (OR = 2.32, 95% CI: 1.11 to 4.87; and OR = 2.48, 95% CI: 0.97 to 6.34, respectively) were slightly more precise than most of the sub-domains.

Table 4 and Figure 3 present the SEHQ health and development outcomes collected for Victorian children. When considering the ORs and confidence intervals by SEHQ domains collectively, there were no clear group effects. Intervention parents appeared more likely than usual care parents to report that their child was unclear to others (OR = 2.18, 95% CI: 1.39 to 3.45), and therefore that their child had any speech or language difficulty (OR = 1.71, 95% CI: 1.15 to 2.55). However, intervention parents were less likely to report concerns about their child's learning, development or behavior (OR = 0.61, 95% CI: 0.47 to 0.80).

Table 5 and Figure 4 present the health service use outcomes for Victorian children. By school transition, more children in the intervention group had accessed health services

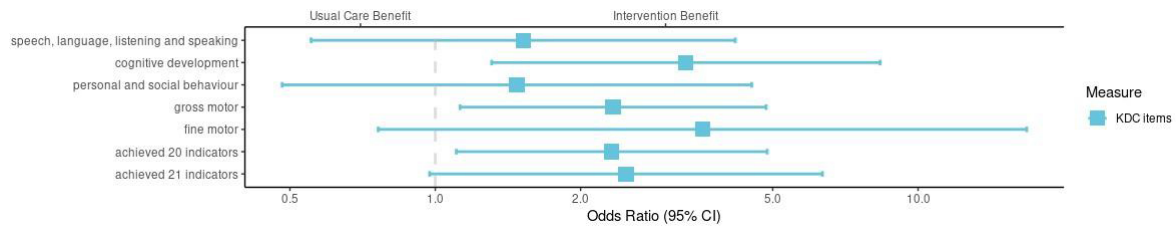
than children in the control group. The largest group differences were for obtaining an allergy diagnosis (OR = 2.00, 95% CI: 1.08 to 3.72), seeing a maternal and child health nurse for the scheduled 3.5-year-old check (OR = 1.41, 95% CI: 0.99 to 2.02), a dentist (OR = 1.69, 95% CI: 1.24 to 2.30), and a speech pathologist (OR = 1.75, 95% CI: 1.1 to 2.79).

Supplementary Table 2 shows that using available case data led to an underestimation of the prevalence of family issues and stressors (Table 2), which is not surprising given that nonresponse is higher in experiencing higher adversity. There were only modest differences in the results between the primary analyses above and the available case analyses (Supplementary Tables 3–5), suggesting that the analyses of group differences were not highly sensitive to the assumptions made about the missing data.

Discussion

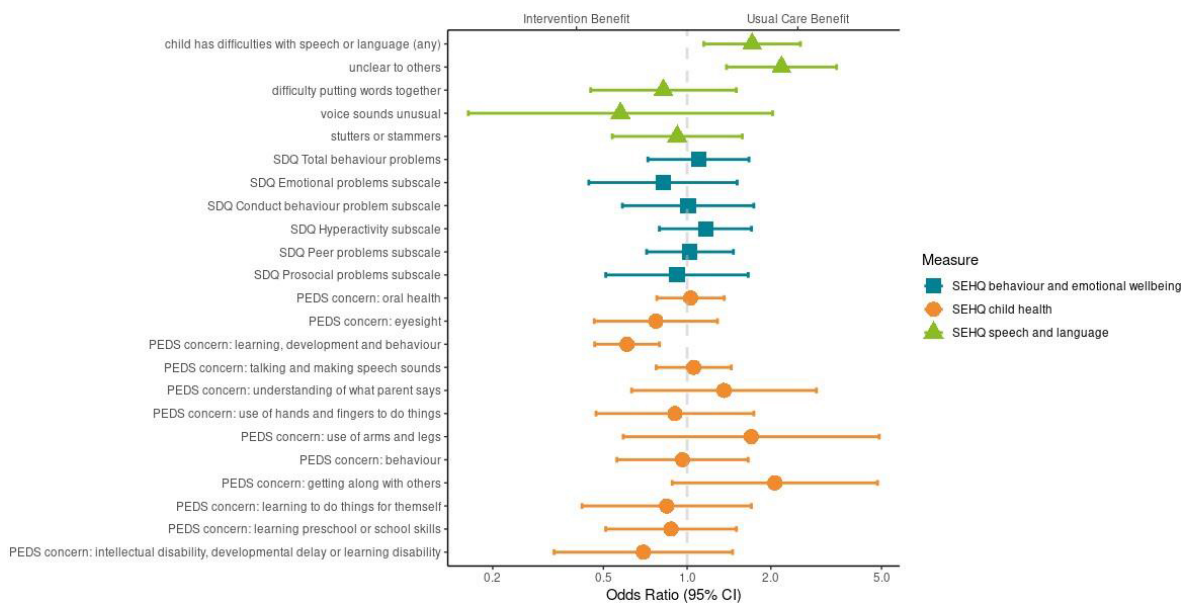
This study conducted the first evaluation of a NHV trial designed for universal health settings using linked administrative data. Despite the small sample sizes and differences between the two jurisdictions in measures and data collection, some intervention benefits were evident. Compared with children assigned to the usual care group, educators of children assigned to the intervention group reported improved child cognitive and gross motor achievement, using the Tasmanian KDC. While more Victorian intervention parents reported that their children's speech was unclear to others, they were less likely to report concerns about their

Figure 2: Results of adjusted logistic regression analyses comparing the trial groups on child outcomes (Tasmania), using inverse probability weighted data (from Table 3)



Inverse probability weighting was used to address missing data for the Tasmanian cohort. Models were adjusted for stratification factors used during randomization (parity, site) and baseline covariates: child gender, family Socio-Economic Index for Areas (SEIFA) score of neighborhood-level disadvantage, maternal age, education antenatal risk count (2 or more of 10 factors), self-efficacy and mental health at baseline. Maternal language other than English was also included for child language outcomes. All regression analyses accounted for effects of nurse clustering using robust estimation.

Figure 3: Results of adjusted logistic regression analyses comparing the trial groups on child outcomes (Victoria), using multiply imputed and inverse probability weighted data (from Table 4)



Multiple imputation and inverse probability weighting were used to address missing data for the Victorian cohort. Models were adjusted for stratification factors used during randomization (parity, site) and baseline covariates: child gender, family Socio-Economic Index for Areas (SEIFA) score of neighborhood-level disadvantage, maternal age, education antenatal risk count (2 or more of 10 factors), self-efficacy and mental health at baseline. All regression analyses accounted for effects of nurse clustering using robust estimation.

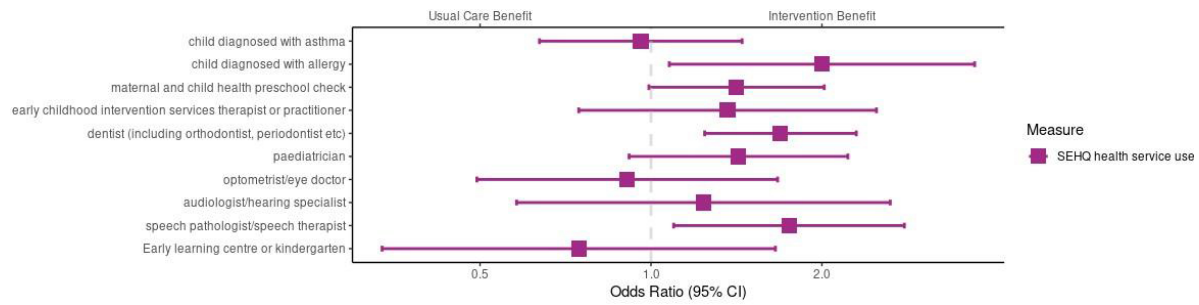
child's learning, development or behavior and also reported using more early health services, including speech pathology, maternal and child health nurse, and dentist appointments, using the Victorian SEHQ.

Consistent with our study, it is common in the peer reviewed NHV literature for trials to have a mix of intervention benefits and no impacts, and less common for benefits to favor the control [12, 36]. In the US, the Department of Health and Human Services is responsible for the Home Visiting Evidence of Effectiveness platform (HomVEE) [37], which reviews the effectiveness of home visiting programs and assigns funding to jurisdictions to implement programs that are deemed effective. The HomVEE criteria for an effective NHV RCT is "statistically significant impacts in two or more of eight outcome domains", such as child development and school readiness, child or maternal health. Despite the often

mixed and modest effects of NHV, the intractable nature of early adversity means NHV is recognized as one of the few effective public health programs for redressing early inequities [8]. HomVEE recognizes right@home (and its core program, MECSH) as an effective model.

In our study, the intervention benefits to child outcomes aligned with our earlier publications of directly-collected data, which found improvements in children's behavior at 5-6 years [16], and learning, reading, and social skills at 6 years [12]. In the current study, more intervention parents reported that their child had language that was unclear to others. It may be that the NHV program increased caregivers' awareness of language issues, which increased referrals and associated service use. There was no evidence of intervention group differences according to the SDQ (Victorian SEHQ), whereas we have previously found reductions (improvements)

Figure 4: Results of adjusted logistic regression analyses comparing trial groups on health service use outcomes (Victoria), using multiply imputed and inverse probability weighted data (from Table 5)



Multiple imputation and inverse probability weighting were used to address missing data for the Victorian cohort. Models were adjusted for stratification factors used during randomization (parity, site) and baseline covariates: child gender, family Socio-Economic Index for Areas (SEIFA) score of neighborhood-level disadvantage, maternal age, education antenatal risk count (2 or more of 10 factors), self-efficacy and mental health at baseline. All regression analyses accounted for effects of nurse clustering using robust estimation.

in parent-reported SDQ Total scores at the 5 and 6 year assessments (effect sizes 0.14 and 0.16, respectively) [12, 16]. However, within the context of 23 comparisons for SEHQ health and development outcomes, and no consistent direction of effects, these apparent differences might represent chance variation. Unlike earlier waves of maternal interviews, the current study also identified increased use of health services by intervention families, which is a promising secondary benefit from an intervention that ended 2-3 years earlier.

The strengths of this study include the rigorous, real-world, and prospective RCT design, and the comprehensive, longitudinal follow-up. Although loss-to-follow-up increased over time, the sample characteristics appeared balanced between groups and follow-up status. This suggests a lack of response bias using linked administrative data. Furthermore, we applied the best practice methods of using multiple imputation and inverse probability weighting approaches to address missing data. There were also limitations. Twelve percent of the RCT cohort were lost to follow-up during the first postpartum year, before consent for data linkage was sought. Inviting consent at enrolment may have overcome some of or all this loss. In addition, despite having consent for data linkage from 86% of participating families when the KDC and SEHQ were completed, linked data were only available for 53%. While the linked measures broadly related to the school-entry outcomes specified by the right@home program logic, items varied in their validity and interpretability, and jurisdictional differences meant that measures could not be harmonized so analysis of the data across the two states reduced precision. These methodological constraints reinforce a limitation of linked administrative data, which is that the available data are not necessarily the best measures for answering the research question [20]. By way of comparison, earlier waves of direct follow-up with right@home RCT cohort achieved 59% retention at 5 years [16], and 47% at 6 years [12], and used valid and reliable measures that were better suited to measuring program effects [14, 21].

Our finding that the usual care group of children experienced high levels of adverse life events and inequitable outcomes by school transition is consistent with a vast body of literature showing that health and development trajectories are driven by social and environmental factors in the first 1000

days [1]. These findings speak to the effectiveness of the initial screening tool administered to identify and recruit women to participate in the program [38, 39] and the value of screening for adversity when an effective response may be offered. It is reassuring that, compared with the state-wide data, similar or higher proportions of families in the right@home cohort (Victoria) accessed early health services. However, the timing, dose and quality of the services are unknown and, as they typically also follow the inverse care law, it may be that they were insufficient to meet families' increased needs. An additional limitation is that the cohorts represented or missed in the state-wide data summaries are undefined, so calling them state-wide makes assumptions about generalizability. It is likely that adversity and child inequities are under-represented, both in the sub-populations who respond to the SEHQ and KDC, and in how respondents answered the questions [9, 20].

Future linked data from Australia's National Assessment Program - Literacy and Numeracy, will provide the final wave of data for the right@home trial and reveal whether intervention impacts are evident on children's academic skills at 8-9 years. The lessons from the current study suggest that there are likely to be limitations to the quality and interpretability of this future data linkage. Understanding any longer-term or larger scale benefits of NHV for high-income countries with universal healthcare will require rigorous evaluations of program rollouts with novel trial designs [40, 41]. Despite NHV being common in Australia, almost no programs are evaluated, and most are being implemented without an evidence base. In contrast, right@home has been designed to be embedded within Australia's universal Child and Family Health Services and delivered across a variety of geographical regions, and has demonstrated immediate and sustained benefits to women, children and their families.

Conclusion

Using linked administrative data to evaluate the Australian right@home randomized trial of nurse home visiting (NHV) identified benefits to children's development outcomes and health service use, providing a useful supplement to the existing evidence base. When designed and delivered well,

NHV can offer important, long-term protective benefits for families experiencing adversity. Given that so few programs make a difference to childhood inequities, policymakers or state agencies should maximize the reach and impact of programs evidenced to make a difference.

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Statement on conflicts of interest

The "right@home" sustained nurse home visiting trial is a research collaboration between the Australian Research Alliance for Children and Youth (ARACY); the Translational Research and Social Innovation (TReSI) Group at Western Sydney University; and the Centre for Community Child Health (CCCH), which is a department of The Royal Children's Hospital and a research group of Murdoch Children's Research Institute. Ownership of the right@home implementation and support license, which is purchased by Australian state governments for roll out for fidelity support, is shared between institutes.

Ethics statement

The Royal Children's Hospital Human Research Ethics Committee in Melbourne, Australia, approved right@home (HREC 32296).

Data availability statement

We invite researchers to request access to study data, including individual participant data and a data dictionary defining each field, from the Melbourne Children's Campus LifeCourse institutional data access platform (<https://lifecourse.melbournechildrens.com/data-access/>) or the governing Royal Children's Hospital HREC (<https://www.rch.org.au/ethics/>). Data will be shared after the necessary approvals (such as approvals from the study representatives, researcher-initiated ethics approval, and data sharing agreements). Related documents, such as

the study protocol, statistical analysis plan, informed consent form, can also be available on request.

Author contributions

Dr Anna Price: conceptualization, methodology, writing – original draft, writing – review & editing, funding acquisition, supervision, project administration

Ms Jiaxin Zhang: validation, formal analysis, data curation, writing – review & editing, visualization

Prof Sharon Goldfeld: conceptualization, methodology, funding acquisition, writing– review & editing

Prof John Carlin: supervision, validation, data curation, writing – review & editing,

Dr Fiona Mensah: conceptualization, methodology, funding acquisition, writing– review & editing

Dr Price is guarantor and corresponding author. They accept full responsibility for the work and the conduct of the study, had access to the data, and controlled the decision to publish. They attest that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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Abbreviations

CI:	confidence intervals
DASS:	Depression Anxiety Stress Scales
IPW:	inverse probability weights
MI:	multiple imputation
NFP:	Nurse Family Partnership
NHV:	nurse home visiting
OR:	odds ratio
PEDS:	Parental Evaluation of Development Status
RCT:	randomized controlled trial
SDQ:	Strengths and Difficulties Questionnaire
SEIFA:	Socio-Economic Index for Areas
UK:	United Kingdom
US:	United States

Supplementary Appendices

Supplementary Table 1: Victorian School Entrant Health Questionnaire (SEHQ) and Tasmanian Kindergarten Development Check (KDC) Measures

Measure	Description
Tasmanian KDC items	
KDC achievement: Speech, language, listening and speaking (7 items)	Proportions of children who met 21 or 20 of the 21 KDC binary (yes/no) items. All "Yes" in the items of: Talks fluently without stuttering, Asks questions, Uses normal voice and pitch, Responds to questions, Speaks in a manner that can be easily understood by adults, Recounts a personal experience in logical sequence, Understands most classroom instructions.
Cognitive development (7 items)	All "Yes" in the items of: Predicts and understands, Recognizes first name in print, Counts to 5 with 1:1 correspondence, can copy and continue a pattern using two items, Can complete an 8-to-12-piece jigsaw puzzle, Sustains attention to complete a variety of tasks, Draws a person with a head, arms and legs.
Personal and social behavior (4 items)	All "Yes" of four items of: Engages in imaginative play, Separates comfortably from parent/carer, Is independent in their toilet routine, Increasingly cooperates with other students in extended play
Gross motor (1 item)	One holistic item representing achievement on 13 indicators "Yes" compared with "No". Examples of indicators included: Walks upstairs one foot to a step; Jumps from a step, box or similar (40 cm high) and lands on two feet, with bent knees; Balances on each foot for 3 to 5 seconds; Uses two hands to catch a beanbag that has been thrown from at least a meter; Kicks a stationary ball in a stipulated direction (e.g. small soccer ball). The Educator makes a holistic assessment that considers all 13 items, including when 1 or 2 indicators are not achieved.
Fine motor (2 items)	All "Yes" in the items of: Constructs a model with 4 to 8 interlocking pieces, Copies a circle (0) and a cross (+) with accuracy.
SEHQ family issues and stressors	
Child affected by: divorce/separated parents	0 "Not at all", "Not stated" or "Not Applicable" 1 "A little" or "A lot"
death of relative/friend	0 "Not at all", "Not stated" or "Not Applicable" 1 "A little" or "A lot"
remarriage of parent	0 "Not at all", "Not stated" or "Not Applicable" 1 "A little" or "A lot"
illness of parent	0 "Not at all", "Not stated" or "Not Applicable" 1 "A little" or "A lot"
illness of sibling	0 "Not at all", "Not stated" or "Not Applicable" 1 "A little" or "A lot"
parent change of job	0 "Not at all", "Not stated" or "Not Applicable" 1 "A little" or "A lot"
parent loss of job	0 "Not at all", "Not stated" or "Not Applicable" 1 "A little" or "A lot"
move to new house	0 "Not at all", "Not stated" or "Not Applicable" 1 "A little" or "A lot"
new baby in home	0 "Not at all", "Not stated" or "Not Applicable" 1 "A little" or "A lot"
History of: alcohol or drug related problems in family	0 "No" 1 "Yes"
abuse to parent	0 "No" 1 "Yes"
abuse to child	0 "No" 1 "Yes"

Continued

Supplementary Table 1: Continued

Measure	Description
child witnessing violence	0 "No" 1 "Yes"
gambling problem in the family	0 "No" 1 "Yes"
mental illness of parent	0 "No" 1 "Yes"
SEHQ speech and language	
Child has difficulties with speech or language	0 "No" 1 "Yes"
unclear to others	0 "No" 1 "Yes"
difficulty putting words together	0 "No" 1 "Yes"
voice sounds unusual	0 "No" 1 "Yes"
stutters or stammers	0 "No" 1 "Yes"
SEHQ development, behavior, and emotional wellbeing	
Strengths and Difficulties Questionnaire (SDQ) Total behavior problems	25-item Strengths and Difficulties Questionnaire (SDQ, 4-to 10-year-old version) [42] assessing Total Difficulties and five subscales: emotional symptoms; conduct problems; hyperactivity; peer problems; and prosocial problems. In its original scale, higher scores indicate worse behavior. The scores are trichotomised into three categories: low, moderate and high risk, which we further dichotomized into "low risk" (0) versus "moderate/high risk"(1) to compare with the SEHQ state-wide report and between trial groups. The cut-points were not available from the Department of Education, but are likely to reflect the original three-band categorization of normative data representing normal, borderline and abnormal scores [43].
SEHQ child health	
Parent concerned about child's:	Ten items drawn from the Parental Evaluation of Developmental Status (PEDS), designed for children aged 0-8 years as a developmental screening test or an informal means to elicit and respond to parent concerns [44].
oral health	0 "No" 1 "Yes"
eyesight	0 "No", if "Blank" 1 "Yes", if "Information provided"
learning, development and behavior	0 "No" 1 "Yes"
talking and making speech sounds	0 "No" 1 "Yes" or "A little"
understanding of what parent says	0 "No" 1 "Yes" or "A little"
use of hands and fingers to do things	0 "No" 1 "Yes" or "A little"
use of arms and legs	0 "No" 1 "Yes" or "A little"
behavior	0 "No" 1 "Yes" or "A little"
getting along with others	0 "No" 1 "Yes" or "A little"
learning to do things for themselves	0 "No" 1 "Yes" or "A little"

Continued

Supplementary Table 1: Continued

Measure	Description
learning preschool or school skills	0 "No" 1 "Yes" or "A little"
intellectual disability, developmental delay or learning disability	0 "No" 1 "Yes"
SEHQ health service access	
Child diagnosed with asthma	0 "No" 1 "Yes"
Child diagnosed with allergy	0 "No" 1 "Yes"
Note, the above two SEHQ variables about children's diagnoses (asthma and allergy) and, because these involve access to health services, they are categorized as health services rather than health outcomes, although they technically relate to both.	
Child attended:	
maternal and child health 3.5-year check	0 "No" 1 "Yes"
early childhood intervention services therapist or practitioner	0 "No" 1 "Yes"
dentist (including orthodontist, periodontist etc.)	0 "No" 1 "Yes"
paediatrician	0 "Not stated" (for whom answered other questions in the survey) 1 "Yes"
optometrist/eye doctor	0 "No" 1 "Yes"
audiologist/hearing specialist	0 "No" 1 "Yes"
speech pathologist/speech therapist	0 "No" 1 "Yes"
kinder in a childcare center or sessional preschool	0 "No" 1 "Yes"



Supplementary Material: Missing data

The primary analysis was performed on an intention-to-treat basis including all children who consented to follow-up, with inverse probability weighting (IPW) and multiple imputation (MI) techniques used to handle the missing data. Around 50% of children did not have linked data, due to non-consent to data linkage, withdrawal, moving to other jurisdictions, and linkage not possible by educational authorities. Therefore, many women from the original sample of 722 had all outcomes missing. In such situations, using both MI combined with IPW techniques is recommended (Seaman, S.R., White, I.R., Copas, A.J. and Li, L., 2012. Combining multiple imputation (MI) and inverse-probability weighting (IPW). *Biometrics*, 68(1), pp.129-137.) [33]. A technique that combines IPW and MI was adopted, following these two major steps:

Step 1. Calculation of weights: Inverse probability weights were calculated by group and state using the samples of 485 (Victoria) and 237 (Tasmania) mothers/children, and adopting a logistic regression model predicting consent to data linkage and successful match, using the following baseline variables (with no missing values): marital status, employment status (yes vs no), nurse (clustering) in the intervention group and LGA in the control group, antenatal risk (≤ 2 risk factors vs >2 risk factors), maternal age, parity (first child vs second or more), LGA, Mental health (Below vs above 85th centile for mental health), DASS Anxiety sub-score, DASS Depression sub-score, and DASS Stress sub-score. Once inverse probability weights were obtained, only children who completed the SEHQ or KDC survey were included in the following step, and in the final analyses.

Step 2. Multiple imputation of missing data for those who participated in the school transition follow-up. This was for Victorian data only as there were no missing values in the Tasmanian linked data. Multiple imputation models were specified including all variables used in the analysis models as well as all the outcomes collected at the school transition follow-up. 30 completed data sets were imputed using multivariate normal regression including all the women who participated in the school transition follow-up. Each dataset resulting from the multiple imputation model (a “quasi-complete dataset” because the data are complete for the included women, but not for those excluded from MI due to not participating in the school follow up) was then analyzed using IPW derived at step 1. IPW reweights data so that it accounts for characteristics of excluded women (those whose children’s educators did not participate in the school transition follow-up and are missing all outcome data).

For Victorian data, by imputing for women with few missing values, while using inverse probability weights to account for excluded women with all missing outcome data, IPW/MI should maintain the efficiency advantage of MI while avoiding possible bias from incorrectly imputing larger blocks of data. Compared with complete case analysis, the variance estimates given by IPW/MI are generally larger as the latter induces uncertainty from the imputation procedure. For Tasmanian data, MI was unnecessary to conduct and IPW was implemented. There were only two records with partially observed outcomes for those with linked data, so these were omitted from the analysis. Lastly, analysis results may be biased if the outcome missingness was dependent on the outcome itself.



Supplementary Table 2: Proportions (available cases) of children experiencing family issues and stressors (Victoria), state-wide in 2020, and for the right@home Usual Care group

Victoria school entrant health Questionnaire (SEHQ) family issues and stressors	2020 State-wide comparison	right@home usual care group
	% (n/53,967) ^a	n/114 (%)
Child affected by:		
divorce/separated parents	4.2	18 (17.5)
death of relative/friend	6.9	9 (8.8)
remarriage of parent	1.5	1 (1.0)
serious illness of parent	2.5	12 (10.5)
serious illness of sibling	1.1	2 (2.0)
parent change of job	4.1	9 (8.7)
parent loss of job	1.7	1 (1.0)
move to new house	6.4	8 (7.8)
new baby in home	3.8	5 (5.0)
History of:		
alcohol or drug related problems in family	3.6	15 (13.6)
abuse to parent	5.4	21 (19.4)
abuse to child	1.9	9 (8.3)
child witnessing violence	3.5	16 (14.8)
gambling problem in the family	0.6	3 (2.8)
mental illness of parent	8.8	25 (22.7)

Summary statistics exclude missing data.

^an for rows not published for state-wide data.

Supplementary Table 3: Proportions for the state and the right@home trial groups (Tasmania), and adjusted regression analyses comparing the two trial groups on child outcomes, using available cases

Tasmanian kindergarten development check (KDC) items (age 4 years) ^a	Descriptive statistics			Adjusted odds ratio comparing the Intervention with the usual care group			
	State-wide comparison	Usual care	r@h NHV intervention	Odds ratio	95% Confidence interval		p-value
	% ^b	n/118 (%)	n/119 (%)		Lower	Upper	
Achieved 20 indicators	75.9%	21 (36.8)	41 (54.7)	2.60	1.28	5.28	0.01
Achieved 21 indicators	60.7%	12 (21.1)	27 (36.0)	3.08	1.07	8.83	0.04
Achieved development domains:							
Speech, language, listening and speaking	n/a	28 (49.1)	46 (61.3)	1.83	0.82	4.12	0.14
Cognitive development	n/a	21 (36.8)	46 (61.3)	3.35	1.35	8.31	0.01
Personal and social behavior	n/a	44 (75.9)	58 (77.3)	1.29	0.36	4.65	0.70
Gross motor	n/a	25 (43.1)	45 (60.0)	3.01	1.45	6.27	0.00
Fine motor	n/a	46 (79.3)	68 (90.7)	4.01	0.99	16.30	0.05

r@h NHV: right@home Nurse Home Visiting, n/a: state-wide data not available.

Descriptive statistics exclude missing data. Models were adjusted for stratification factors used during randomization (parity, site) and baseline covariates: child gender, family Socio-Economic Index for Areas (SEIFA) score of neighborhood-level disadvantage, maternal age, education antenatal risk count (2 or more of 10 factors), self-efficacy and mental health at baseline. Maternal language other than English was also included for child language outcomes. All regression analyses accounted for effects of nurse clustering using robust estimation.

^aChild scored 'yes' (achieving) to all items in Tasmanian Kindergarten Development Check (KDC) domain items.

^bDenominator and numerator not available. Note, the 2020 KDC outcome was impacted by COVID-19, as only one assessment was conducted. As a result, comparisons with 2021 and previous years should be exercised with caution. In 2019, 67.8% of the assessed cohort achieved all 21 indicators.

Supplementary Table 4: Proportions for the state and the right@home trial groups (Victoria), and adjusted regression analyses comparing the two trial groups on child outcomes, using available cases

Victoria school entrant health questionnaire (SEHQ) (age 5-6 years)	Descriptive statistics			Adjusted odds ratio comparing the intervention with the usual care group			
	State-wide comparison	Usual care	r@h NHV intervention	Odds ratio	95% Confidence interval		p-value
	n/53,967 (%)	n/114 (%)	n/137 (%)		Lower	Upper	
Child has difficulties with speech or language (any)	8,645 (16.0)	20 (17.5)	31 (22.6)	1.38	0.90	2.10	0.14
unclear to others	6,495 (12.0)	14 (12.3)	27 (19.7)	1.75	1.08	2.83	0.02
difficulty putting words together	3,271 (6.1)	11 (9.6)	9 (6.6)	0.70	0.38	1.28	0.24
voice sounds unusual	1,273 (2.4)	5 (4.4)	3 (2.2)	0.40	0.10	1.61	0.20
stutters or stammers	2,246 (4.2)	9 (7.9)	10 (7.3)	0.73	0.37	1.46	0.38
Behavior and emotional wellbeing^a							
SDQ Total difficulties: moderate risk	3,145 (5.8)	10 (8.9)	12 (9.0)	0.84	0.49	1.44	0.53
SDQ Total difficulties: high risk	3,982 (7.4)	21 (18.8)	22 (16.4)				
SDQ Emotional problems: moderate risk	7144 (13.2)	11 (9.8)	16 (11.9)	1.08	0.70	1.66	0.74
SDQ Emotional problems: high risk		17 (15.2)	21 (15.7)				
SDQ Conduct problem: moderate risk	11,969 (22.2)	21 (18.8)	24 (17.9)	0.69	0.38	1.26	0.23
SDQ Conduct problem: high risk		27 (24.1)	26 (19.4)				
SDQ Hyperactivity: moderate risk	7,951 (14.7)	11 (9.8)	7 (5.2)	0.95	0.57	1.57	0.83
SDQ Hyperactivity: high risk		18 (16.1)	29 (21.6)				
SDQ Peer problems: moderate risk	9,848 (18.2)	17 (15.2)	23 (17.2)	1.03	0.74	1.42	0.87
SDQ Peer problems: high risk		17 (15.2)	19 (14.2)				
SDQ Prosocial problems: moderate risk	4,151 (7.7)	12 (10.7)	10 (7.5)	0.98	0.77	1.24	0.85
SDQ Prosocial problems: high risk		4 (3.6)	7 (5.2)				
Child health and development							
PEDS Parent concerned about child's:							
oral health	8,754 (16.2)	20 (18.0)	23 (17.4)	0.80	0.52	1.21	0.29
eyesight	4,531 (8.4)	18 (16.2)	15 (11.3)	0.73	0.45	1.19	0.21
learning, development and behavior	n/a	56 (49.1)	50 (36.5)	0.56	0.43	0.72	0.00
talking and making speech sounds	n/a	31 (27.9)	34 (25.6)	0.87	0.59	1.29	0.49
understanding of what parent says	n/a	10 (8.9)	13 (9.8)	1.02	0.53	1.96	0.96
use of hands and fingers to do things	n/a	11 (9.9)	11 (8.2)	0.80	0.41	1.56	0.52
use of arms and legs	n/a	6 (5.4)	8 (6.0)	1.32	0.55	3.18	0.53
behavior	n/a	30 (27.0)	32 (24.2)	0.83	0.48	1.45	0.52
getting along with others	n/a	17 (15.2)	26 (19.7)	1.62	0.69	3.80	0.26
learning to do things for themselves	n/a	11 (9.8)	7 (5.2)	0.53	0.21	1.36	0.19
learning preschool or school skills	n/a	12 (10.9)	12 (9.0)	0.68	0.34	1.35	0.27
intellectual disability, developmental delay or learning disability	n/a	17 (15.5)	13 (9.8)	0.59	0.30	1.16	0.13

PEDS: Parental Evaluation of Developmental Status; r@h NHV: right@home Nurse Home Visiting. SDQ: Strengths and Difficulties Questionnaire. n/a: state-wide data not available.

Descriptive statistics exclude missing data. Subscale scoring (SDQ, PEDS) was completed by school nurses and subscale scores were not available for linkage. Models were adjusted for stratification factors used during randomization (parity, site) and baseline covariates: child gender, family Socio-Economic Index for Areas (SEIFA) score of neighborhood-level disadvantage, maternal age, education antenatal risk count (2 or more of 10 factors), self-efficacy and mental health at baseline. Maternal language other than English was also included for child language outcomes. All regression analyses accounted for effects of nurse clustering using robust estimation.

^an for rows not published for state-wide SDQ data. SDQ dichotomized as moderate/high versus low risk for analysis.

Supplementary Table 5: Proportions for the state and the right@home trial groups (Victoria), and adjusted regression analysis comparing the trial groups on child health service use, using available cases

Victoria school entrant health questionnaire (SEHQ) (age 5–6 years)	Descriptive statistics			Adjusted odds ratio comparing the intervention with the usual care group			
	State-wide comparison	Usual care	r@h NHV intervention	Odds ratio	95% Confidence interval		p-value
	n/53,967 (%)	n/114 (%)	n/137 (%)		Lower	Upper	
Child diagnosed with asthma	5,502 (10.2)	21 (18.9)	29 (21.6)	1.02	0.65	1.60	0.94
Child diagnosed with allergy	4,614 (8.6)	9 (8.0)	18 (13.4)	2.53	1.20	5.33	0.01
Child attended:							
maternal and child health preschool check	38,073 (70.5)	89 (86.4)	110 (90.9)	1.62	1.17	2.24	0.00
early childhood intervention services therapist or practitioner	2,786 (5.2)	8 (7.0)	11 (8.0)	1.16	0.64	2.09	0.62
dentist (including orthodontist, periodontist etc)	26,932 (49.9)	54 (47.4)	76 (55.5)	1.59	1.16	2.18	0.00
paediatrician	6,638 (12.3)	16 (14.0)	20 (14.6)	1.37	0.87	2.17	0.17
optometrist/eye doctor	8,753 (16.2)	27 (23.7)	33 (24.1)	0.93	0.51	1.68	0.80
audiologist/hearing specialist	4,113 (7.6)	12 (10.5)	17 (12.4)	1.32	0.63	2.76	0.45
speech pathologist/speech therapist	6,071 (11.2)	19 (16.7)	28 (20.4)	1.38	0.84	2.25	0.20
early learning center or kindergarten	46,788 (86.7)	106 (93.0)	125 (91.2)	0.79	0.38	1.66	0.54

r@h NHV: right@home Nurse Home Visiting.

Descriptive statistics exclude missing data. Models were adjusted for stratification factors used during randomization (parity, site) and baseline covariates: child gender, family Socio-Economic Index for Areas (SEIFA) score of neighborhood-level disadvantage, maternal age, education antenatal risk count (2 or more of 10 factors), self-efficacy and mental health at baseline. Maternal language other than English was also included for child language outcomes. All regression analyses accounted for effects of nurse clustering using robust estimation.

