International Journal of Population Data Science

Journal Website: www.ijpds.org

Use of administrative record linkage to examine patterns of universal early childhood health and education service use from birth to Kindergarten (age four years) and developmental vulnerability in the Preparatory Year (age five years) in Tasmania, Australia

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Submission History

Submitted:	29/05/2021
Accepted:	26/10/2021
Published:	19/01/2022

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Abstract

Background
In Australia, the health and education sectors provide universal early childhood services for the same population of children. Therefore, there is a strong imperative to view service use and outcomes through a cross-sectoral lens to better understand and address the service needs of young children and their families.

Objectives
To investigate patterns of health and education service use from birth through Kindergarten (age four years), the associations with cumulative risks, and developmental vulnerability in the first year of full-time school (age five years).

Methods
A retrospective cohort study that used population-wide linkage of health and education administrative data records for 5,440 children with a Tasmanian 2015 Australian Early Development Census (AEDC) record who were born in Tasmania (2008–2010).

Results
Four service use patterns were identified: Regular (46% of children), Declining (24%); Low (18%); and Selective service use (12%). Regular service use (aOR 0.8, 95% CI 0.7 to 0.9), adjusted for cumulative risks, was associated with decreased odds of developmental vulnerability, compared to the other service use groups. Low (OR 6.1, 95% CI 4.5 to 8.2) and Declining service use (OR 2.5 95% CI 1.9 to 3.4) were more likely for children with the highest levels of cumulative risks. Low and Declining service use, adjusted for cumulative risks were associated with increased odds of developmental vulnerability, compared to the Regular service use group.

Conclusion
This study provides a whole population view of the differential use of universal services and the complex risk circumstances that influence service use. The association between patterns of multiple risk and service use points to barriers to service use, and the varying level of developmental vulnerability within each service use group draws attention to children who may benefit from higher sustained participation in core health and education services across the whole of early childhood.

Keywords
child development; universal services; child health; education; cumulative risks

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https://doi.org/10.23889/ijpds.v6i3.1681

Introduction

The period from birth to age five years, the first 2000 days, is a sensitive period for a child's neurodevelopment and a window of opportunity for interventions to build a strong foundation for children's future health, development and learning [1, 2]. Young children's individual characteristics, those of their parents, environments, care, relationships, experiences and opportunities have a lasting influence on their future. In the presence of robust brain structure and function, nurturing care and safe and stimulating environments, the growth and change in young children's physical, cognitive, language, social and emotional development occurs at a rapid rate. The neuroplasticity that underpins children's capacity for prodigious growth and change also means that their trajectories can be derailed by exposure to risk factors relating to the child, their parents, families and communities. Single risk exposures tend not to compromise children's development [3], with the exception of socio-economic disadvantage [4–6], but pose a significant threat to children's developmental progress when they cluster together [6–11].

Early childhood is a critical 'window of opportunity' for early interventions to promote positive child development outcomes and to address risk factors that impede children's developmental progress [2, 12, 13]. Universal child health and early education services, starting from birth, are regarded as one of the best investments that governments can make in establishing a strong foundation for children's health, development and learning [14]. The aim of universal early childhood health and education services is to support children to achieve optimal health, development and learning in the preschool years. Universal early childhood services are intended to reach all children in the population and are designed around the principle of primary prevention, equity of access and flexible service delivery, proportionate to the developmental needs of individual children and their caregivers. Universal services also play an important role in referring children and families to specialist and targeted services within and between the health and education sectors [15, 16].

In practice, a truly proportionate universal early childhood service system [16] would be used more extensively by children with high service needs (i.e., high risk exposure), than children with lower risk exposures and lower service needs [5]. A confronting finding, from studies that have investigated equity in access to and use of early childhood services, is that children with the highest service needs (i.e., highest risk exposures) are less likely to use these services than their more advantaged peers. Inequitable access to and use of universal early childhood services has been observed in child health services [17, 18], primary healthcare services [19], early childhood education and care [20–22], and specialist services [19, 23]. These findings indicate that the inverse care law is in operation and contributes to widening inequalities in children's developmental outcomes [7, 24, 25].

Universal child health and early education services in Australia

In Australia, and other high income countries, core primary prevention services for young children include the provision of a universal child health service, led by child health nurses [26], and high-quality Early Childhood Education and Care (ECEC), led by early childhood teachers [27]. In Australia, all children are offered child health services as part of state and territory government funded primary health services. These services start in infancy and are free-of-charge to children's caregivers at point of use. There is no legislative requirement for families to use these services and participation is voluntary [28].

In Australia, all children are offered 600 hours of ECEC in the year before they start full-time school. This is equivalent to 15 hours of play-based learning a week for 40 weeks of the year in school settings. There is no legislative requirement for families to enrol children in ECEC and participation is voluntary [27].

Parents and the home learning environment are the most proximal and formative influence on young children's development [12]. In Australia, parent-child early education programmes are provided by government, non-government and not-for-profit organisations. There is no national universal parent-child early education programme and the provision of parent-child early education programmes is the responsibility of state and territory governments. The delivery of these programs by government departments is guided by the Commonwealth Department of Education and Training Family-School Partnerships Framework [29] and Early Years Learning Framework [30]. Tasmania is the only state/territory in Australia that delivers a universal parent-child early education programme. Launching into Learning (LiL) is a school-based early learning program for children from birth to age 4 years developed by the Tasmanian Department of Education [31].

A Siloed view of early childhood health and education services

The health and education sectors provide complementary universal services for the same population of children and their caregivers [15, 30, 32], yet research has largely focused on service use within the health or education sector and not across both sectors, effectively dividing early childhood into silos. Studies that have used population-wide linkage of administrative data records to investigate patterns of participation and non-participation in universal nurse-led child health checks [17, 18] and early childhood education and care [20, 21], have reported socio-economic inequalities in access and use of these services. This siloed view of universal service coverage limits opportunities for cross-sectoral collaboration and coordinated efforts to improve children's access and use of core universal services.

Given the consistent finding that the burden of developmental vulnerability is concentrated in the most disadvantaged population groups combined with the convergent evidence that the uptake of universal child health and early education services favours more advantaged children; the logical next step is to investigate service use and developmental outcomes at the interface of the health and education universal service systems. The overarching aim of this study was to produce evidence about children's service use across the health and education sectors with the aim of supporting cross-sectoral collaboration and coordination of core universal early childhood services.

Research aims

The aims of this study were to investigate (1) patterns of health and education service use from birth through Kindergarten (age four years); (2) associations between cumulative risks and service use patterns; and (3) associations between service use patterns and developmental vulnerability in the first year of full-time school (age five years).

Methods

Data sources and study population

The study was conducted in Tasmania, Australia. The study used a linked dataset comprising five de-identified unit-record administrative datasets collected by the Tasmanian Department of Health (Tasmanian Perinatal Data Collection, Child Health and Parenting Service), Tasmanian Department of Education (Launching into Learning, Kindergarten) and the Commonwealth Department of Education and Training (Australian Early Development Census).

Data sources

Unit-record-level identifying information from the five linked datasets was provided by the Tasmanian Government Department of Health and Department of Education data custodians and the Australian Early Development Census (AEDC) Data Management Agency to the Tasmanian Data Linkage Unit (TDLU) [33] and a linkage key map was created by the TDLU using probabilistic linkage methods [34]. First, linkage probability weights were calculated to identify possible matches among individuals in the five datasets. The TDLU uses a combination of fields including source system identifier, full name, date of birth, gender, and residential address. Match weight scores were calculated for each linkage field, based on field agreements, disagreements and missing data. Matches, possible matches and non-matches were calculated using total weight score thresholds. Second, a clerical review process involved manually checking record pairs/groups identified as potential matches following probabilistic linkage. Following this two-step process, the TDLU returned the source identifiers, with the addition of the unique project linkage keys, to the data custodians who combined the identifiable data set and the unique linkage key with their complete data set. Each data custodian extracted a de-identified research data set that contained the selected variables and the unique linkage keys and released the research data set to the researchers. The researchers linked unit record-level variables across the five datasets, using the unique linkage key, to create the data set for this study.

Study population

The study population comprised 5,440 children who had a Tasmanian 2015 AEDC instrument collected in the first year of full time school at age five years (i.e., Preparatory Year) and a Tasmanian Perinatal Baby Record collected in all Tasmanian public and private hospitals for all live births and stillbirths of at least 20 weeks gestation or weighing at least 400 grams. In the Australian Early Development Census National Report 2015, there were 6,425 children (99% of eligible children) with a 2015 AEDC instrument with a Tasmanian postcode [35], compared to 6,419 children in the research dataset. This is indicative of high coverage of linkage of the Tasmanian 2015 AEDC data. The percentage of children classified as developmentally vulnerable was 20.9% in the research dataset, compared to 21.0% of Tasmanian children, in the AEDC National Report 2015 [35]. Of the 6,419 children with a Tasmanian 2015 AEDC record, there were 979 children who did not have a Tasmanian Perinatal Baby Record. These children were likely to have migrated to Tasmania from interstate or overseas, consistent with migration data for Tasmania [36]. Most children were born in 2009 (97.8%) with some born in 2007 (0.1%), 2008 (1.8%), and 2010 (0.3%). The mean age of the children when the 2015 AEDC instrument was collected was five years and seven months (range 4.7 to 8.4 years).

Outcome measure – the Australian early development census

The AEDC is a national teacher-report measure of child development collected in children's first year of full-time school enrolment across government, independent and Catholic schools. In Tasmania, children start full-time school (Preparatory Year) in the year when they are five years of age on or by 1 January, in any year. The AEDC also collects school and demographic variables from state/territory governments, independent and Catholic schools. The AEDC comprises 96 licenced items across five child development domains: Physical health and wellbeing, social competence, emotional maturity, language and cognitive skills (school-based) and communication skills and general knowledge, and has satisfactory validity and reliability [37]. Children receive a score between zero and ten, where zero is the most developmentally vulnerable. Scores are classified into percentiles, determined using cut-off points established in 2009 [38].

Children who score below the 10th percentile on one or more AEDC domain(s) are classified as developmentally vulnerable (DV1). This was the outcome measure used in this study. Cut-off scores are based on all children who participated in the first national AEDC data collection in 2009, excluding children with special needs, and apply to all AEDC data collections. Children with special needs are those who require special assistance due to a medical diagnosis, a diagnosis of a chronic medical, physical or intellectually disabling condition. Children with special needs are not included in the calculation of the results and do not receive a domain category (e.g., developmentally on track, at risk or vulnerable). The number of children with special needs is reported in each AEDC collection. Children who are younger than 4 years receive a domain score, but are not assigned to a category as their age cannot be validated and cut-offs are age-dependent. Children whose teachers have answered less than 75% of the items in any domain will not receive a score at all. If the teacher indicated that a child had been in their class for less than one month and they did not know the child well enough to complete the AEDC instrument, then that child will have no instrument data [35].

Cumulative risk index

The study used a cumulative risk index [3] comprising 11 binary birth, health behaviour and socio-demographic risk variables. Variable selection was based on evidence of associations between the risk factors and developmental vulnerability in previous studies that used population-level linkage of administrative data records [8, 39, 40], including a prior study of this study population [41]. The risk factors identified in previous studies include biological risk factors (e.g., low birth weight), sociodemographic risk factors (e.g., young maternal age, low maternal education, socioeconomic disadvantage), and health behaviour risks (e.g., smoking in pregnancy) [6, 39, 40]. The risk factors selected for modelling in this study feature in international child development monitoring frameworks [14, 42] and Australian monitoring frameworks. Parental educational attainment is monitored in Australia's National Assessment Program [43], socioeconomic disadvantage is monitored in Australia's Health reporting framework [44], and low birth weight, teenage mothers, Indigenous mothers, parity, smoking in pregnancy, alcohol use in pregnancy and language background other than English, are monitored in Australia's Mothers and Babies reporting framework [45]. For all the risk variables, children were coded with '1' if the risk factor was present and '0' if the risk factor was not present. The cumulative risk index was computed by summing the number of risk exposures (0-11). Cumulative risks were reported as zero, one, two, three and four or more risks.

Birth risks

The risk variables obtained from the Perinatal Baby Records were: low birth weight (less than 2500 grams), low gestational age (less than 37 completed weeks) and multiple birth.

Health behaviour risks

The risk variables obtained from the Perinatal Mother Records were: smoking in pregnancy and alcohol use in pregnancy.

Sociodemographic risks

The risk variables obtained from the Perinatal Mother Records were: teenage mother at the birth of the child (less than 20 years), Indigenous mother, three or more previous pregnancies, and Index of Relative Socio-Economic Disadvantage quintile 1 (most disadvantaged). The risk variables obtained from the AEDC records were: main carer's education less than Year 11 and language other than English spoken at home by the child.

Universal child health and early education services in tasmania

The Tasmanian Government provides three universal child health and early education services for all children from birth through Kindergarten (age four years). The three universal services are the Child Health and Parenting Service (CHaPS), Launching into Learning (LiL) and Kindergarten. The CHaPS is provided by the Tasmanian Department of Health and LiL and Kindergarten are provided by the Tasmanian Department of Education. Participation in these services is voluntary and free-of-charge to caregivers. The (CHaPS) [46] provides health, development and well-being assessment for children; parenting information, advice and support for caregivers; perinatal mental health screening and well-being support for caregivers and Child Health Assessments (CHAs) for children. The CHaPS is delivered by child health nurses who work across a range of settings including standalone child health clinics, clinics based in community health centres, Child and Family Centres and government schools. Service delivery and practice is guided by the National Framework for Universal Child and Family Health Services [47]. Following the precedent in the literature [17, 18], this study focused on one aspect of child health service delivery, children's use of CHAs.

Child Health Assessments (CHAs)

The Child Health and Parenting Service provides eight CHAs scheduled at these ages: two weeks, four weeks, eight weeks, four months, six months, twelve months, two years and four years (eight CHAs in total). The CHAs are offered at the recommended ages for screening and surveillance in line with national child health screening and surveillance guidelines [47]. The recommended schedule is that all children complete 8 CHAs. Child health nurses can schedule review or repeat CHAs where indicated by a developmental screening result or at the request of parents. The first CHA, at 2 weeks, is offered as a home visit and subsequent CHAs usually take place at child health centres. Additional home visiting, beyond the 2 week CHA can be provided for children and families on a needs basis. For the purposes of this study, each CHA was counted as a single service event (eight service events in total). Children were coded with '1' for participation and '0' for non-participation in each of the eight CHAs.

Launching into Learning (LiL)

LiL is a school-based early learning program for children from birth to age four years developed by the Tasmanian Department of Education. LiL has been universally available in all Tasmanian Government schools since 2012. LiL sessions are planned and delivered by early childhood teachers to groups of children and their caregivers. Service delivery is guided by the Family-School Partnerships Framework [29] and the Early Years Learning Framework [30]. The number of sessions available each week of the school term is determined by the school [31]. For the purposes of this study, LiL was counted as a single service event and children were coded with '1' for participation in LiL and '0' for non-participation in LiL.

Kindergarten

In Tasmania, all children are offered 15-hours a week of ECEC for 40 weeks of the calendar year in government schools. In any given year, children are eligible to start Kindergarten in the year when they are 4 years of age on or by 1 January [48]. Kindergarten sessions comprise play-based learning activities that are planned and delivered by early childhood teachers for 40 weeks of the calendar year. For the purposes of this study, Kindergarten was counted as a single service event and children were coded with '1' for participation in Kindergarten and '0' for non-participation in Kindergarten.

Service use measure

The service use measure comprised the child's first recorded use (yes/no) of each of the eight Child Health Assessments (two weeks, four weeks, eight weeks, four months, six months, twelve months, two years and four years), use of Launching into Learning (yes/no), and use of Kindergarten (yes/no) for a total of ten possible service events. For each of the ten service events, children were coded with '1' for participation and '0' for non-participation. Thus each child could record zero to ten service events in total across the first 4 years of childhood. This approach to measuring service use is consistent with Australian government population monitoring and reporting systems [28, 35, 45] and studies with a principal interest in quantifying and understanding differential use of universal early childhood services [17–19, 49, 50].

Statistical analysis

The analysis proceeded in four steps: (1) Latent Class Analysis (LCA) was used to identify and describe service use groups; (2) information from the latent class model was used to assign children to service use groups; (3) multinomial logistic regression was used to estimate the odds of service use group membership associated with cumulative risks, relative to the reference group; (4) multivariable logistic regression was used to estimate the adjusted odds of developmental vulnerability on one or more AEDC domains associated with service use group membership, relative to the reference group. All LCA analyses were conducted in SAS PROC LCA V1.3.2 [51]. The multinomial logistic regression and multivariable logistic regression analyses were conducted in SAS V.9.4 [52].

The proportions of missing data for risk factors ranged from 0.02% (birth weight) to 24.89% (primary caregiver education). Missing values for risk factors were imputed using PROC MI in SAS V.9.4 [52]. We generated 25 imputed data sets, with results averaged according to Rubin's rule [53], using PROC MIANALYZE. To account for arbitrary patterns of missing-ness, we used the fully conditional specification method [54]. No auxiliary variables were added to the imputation process. AEDC outcomes were not imputed. The distribution of developmental vulnerability on one or more AEDC domains (DV1) and individual risk factors for children with observed and imputed data is reported in Supplementary Appendix A.

Results

Service use groups

Service use in this population was heterogenous. Across ten service events, 2^{10} (1,024) patterns of service use and non-use were possible, and 493 combinations were observed in the data.

LCA describes a series of distinct classes (i.e., groups) and assigns an item-response probability within each class [55–57]. Entropy and the A-BIC (Adjusted Bayesian information criterion) were used as the statistical measures of model fit in this paper. Given the A-BIC indicated a 5-class model and Entropy suggested a 2-class model, all options between two and five classes were considered for interpretability. A 4-class model was selected on the basis of statistical criteria, reported in Supplementary Appendix B, and the researchers' judgements that: The 4-class model produced a clear distinction between classes, all classes were substantial in size, and each class could be assigned a meaningful descriptive label [58]. Information from the LCA model was used to assign children to each of the four classes. Individual children were assigned to latent classes based on their maximum posterior probability [59].

The four latent classes were given descriptive labels based on the pattern of service use that distinguished each class: Regular service use, Low service use, Declining service use and Selective service use. Figure 1 shows the probability of participation in each service event by service use group, and Table 1 shows the distribution of service events by service use group.

Regular service use group

Children assigned to the Regular service use group (46% of the sample) participated in an average of 8.4 (95% CI 8.3 to 8.4) service events, higher than the population average of 6.5 (95% CI 6.4 to 6.5) service events. This group had the highest service use of all the groups across the 10 service events (Figure 1). The Regular service use group was the reference group for this study.

Declining service use group

Children assigned to the Declining service use group (24% of the sample) participated in an average of 5.6 (95% CI 5.6 to 5.7) service events, lower than the population average of 6.5 (95% CI 6.4 to 6.5) service events. Service use in this group declined after the 8-Week Child Health Assessment, increased for Launching into Learning, declined for the 4-Year Child Health Assessment, and increased for Kindergarten (Figure 1).

Low service use group

Children assigned to the Low service use group (18% of the sample) participated in an average of 3.1 (95% CI 3.0 to 3.1) service events, less than half the population average of 6.5 (95% CI 6.4 to 6.5) service events. Service use in this group was consistently lower than the other groups across all service events (Figure 1).

Selective service use group

Children assigned to Selective service use group (12% of the sample) participated in an average of 6.2 (95% CI 6.2 to 6.3) service events, slightly lower than the population average of 6.5 (95% CI 6.4 to 6.5) service events (Figure 1). Service use in this group was not consistently regular, declining nor low, and service use varied substantially between specific service events.

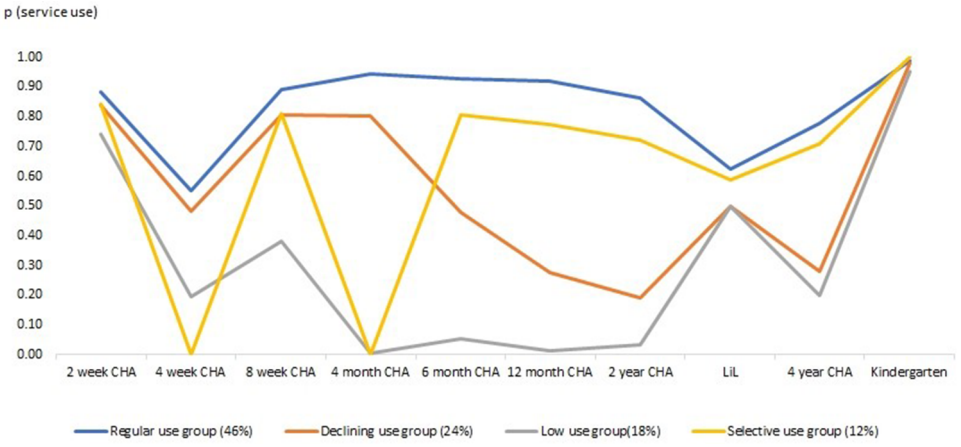
Cumulative risks

In this study population, the number of risks varied from zero to eight risks. 27% of children were exposed to zero risks, 29% to one risk, 22% to two risks, 13% to three risks and 9% to four or more risks.

Table 1: The distribution of service events by service use group

Class	Regular service use group (46%)	Declining service use group (24%)	Low service use group (18%)	Selective service use group (12%)	Population average service use
	proportion (95% CI)	proportion (95% CI)	proportion (95% CI)	proportion (95% CI)	proportion (95% CI)
2-Week CHA	0.88 (0.87 to 0.90)	0.84 (0.82 to 0.86)	0.74 (0.71 to 0.77)	0.84 (0.81 to 0.87)	0.84 (0.83 to 0.85)
4-Week CHA	0.55 (0.53 to0.57)	0.48 (0.46 to 0.51)	0.19 (0.17 to 0.22)	0.00 (0.00 to 0.00)	0.40 (0.38 to 0.41)
8-Week CHA	0.89 (0.88 to 0.90)	0.81 (0.78 to 0.83)	0.38 (0.35 to 0.41)	0.80 (0.78 to 0.84)	0.77 (0.75 to 0.77)
4-Month CHA	0.94 (0.93 to 0.95)	0.80 (0.78 to 0.82)	0.00 (0.00 to 0.01)	0.00 (0.00 to 0.00)	0.62 (0.60 to 0.63)
6-Month CHA	0.92 (0.91 to 0.94)	0.48 (0.45 to 0.51)	0.05 (0.04 to 0.07)	0.80 (0.77 to 0.84)	0.65 (0.63 to 0.66)
12-Month CHA	0.92 (0.91 to 0.93)	0.28 (0.25 to 0.30)	0.01 (0.00 to 0.02)	0.77 (0.74 to 0.80)	0.58 (0.57 to 0.60)
2-Year CHA	0.86 (0.85 to 0.88)	0.19 (0.17 to 0.21)	0.03 (0.02 to 0.05)	0.72 (0.68 to 0.75)	0.53 (0.52 to 0.55)
LiL	0.63 (0.60 to 0.64)	0.50 (0.47 to 0.53)	0.50 (0.47 to 0.53)	0.59 (0.55 to 0.63)	0.57 (0.55 to 0.58)
4-Year CHA	0.78 (0.76 to 0.79)	0.28 (0.26 to 0.31)	0.20 (0.17 to 0.22)	0.71 (0.67 to 0.74)	0.55 (0.53 to 0.56)
Kindergarten	0.99 (0.98 to 0.99)	0.98 (0.97 to 0.99)	0.95 (0.94 to 0.97)	1.00 (0.99 to 1.00)	0.98 (0.98 to 0.99)
Total number of service events	8.4 (8.3 to 8.4)	5.6 (5.6 to 5.7)	3.1 (3.0 to 3.1)	6.2 (6.2 to 6.3)	6.5 (6.4 to 6.5)

Figure 1: Probability of service event by latent class



The distribution of cumulative risks varied by service use group. Children in the Regular service use group were exposed to an average of 1.2 risks (95% CI 1.2 to 1.3), children in the Declining service use group were exposed to an average of 1.7 risks (95% CI 1.6 to 1.7), children in the Low service use group were exposed to an average of 2.0 risks (95% CI 1.9 to 2.1), and children in the Selective service use group were exposed to an average of 1.4 risks (95% CI 1.3 to 1.5).The distribution of individual and cumulative risks by service use group is reported in Supplementary Appendix C.

Associations between cumulative risks and service use group membership

Multinomial logistic regression was used to examine the associations between cumulative risks (zero to four or more risks) and service use group membership. Regular service use was the reference category. Table 2 shows the odds of service use group membership associated with increasing levels of cumulative risks. The odds of Declining service use group membership increased with two or more risks. The odds of Low service use group membership increased with one, two, three, and four or more risks. The odds of Selective service use group membership increased with three or more risks.

Developmental vulnerability on one or more AEDC domains (DV1) in the preparatory year

In this study population, 20.9% of children were classified as developmentally vulnerable on one or more AEDC domains, compared to 22.0% nationally (39). In the Regular service use group 411 (17.2%) children were classified as developmentally vulnerable: 295 (24.2%) children in the Declining service use group; 270 (28.1%) children in the Low service use group; and 111 (17.3%) children in the Selective service use group.

Associations between service use group membership and developmental vulnerability on one or more domain (DV1) at age 5 years (Preparatory Year)

The logistic model in Table 3 shows the odds of developmental vulnerability associated with service group membership, after adjusting for cumulative risks. The Regular service use group was the reference group. Membership of the Declining service use group, the Low service use group, but not the Selective use group, was associated with increased odds of developmental vulnerability, relative to the Regular service use group. Membership of the Regular service use group, adjusted for cumulative risks, was associated with decreased odds of

Table 2: Associations between cumulative risks and declining, low and selective service use group membership, relative to the regular service use group

	Declining use group (24%)		Low use group (18%)		Selective use group (12%)	
	OR 95% CI	p value	OR 95% CI	p value	OR 95% CI	p value
0 risks	1		1		1	
1 risk	1.1 (0.9, 1.4)	0.3052	1.7 (1.3, 2.2)	<.0001	1.1 (0.8, 1.3)	0.6444
2 risks	1.6 (1.3, 2.0)	<.0001	2.9 (2.3, 3.7)	<.0001	1.2(0.9, 1.5)	0.2125
3 risks	2.5 (2.0, 3.3)	<.0001	5.3 (4.0, 7.0)	<.0001	1.5 (1.1, 2.1)	0.0096
4 or more risks	2.5 (1.9, 3.4)	<.0001	6.1 (4.5, 8.2)	<.0001	1.5 (1.0, 2.1)	0.0368

Table 3: Associations between service use group membership and developmental vulnerability (DV1), adjusted for cumulative risks[1] [2]

Service Use Group	aOR	p value
Regular use group (46%)	1	
Declining use group (24%)	1.3 (1.1 to 1.6)	0.0007
Low use group (18%)	1.5 (1.2 to 1.8)	<.0001
Selective use group (12%)	0.9 (0.8 to 1.2)	0.6556

[1]228 cases had missing AEDC domain categories, of which 221 were children with special needs.
[2]Adjusted for cumulative risks (zero, one, two, three, or four or more risks).

developmental vulnerability (aOR 0.8, 95% CI 0.7 to 0.9), compared to the other service use groups.

Discussion

This study investigated patterns of universal health and education service use from birth through Kindergarten (age four years), associations between cumulative risks and service use, and associations between service use and developmental vulnerability in the first year of full-time school (age five years).

Four distinct service use patterns were identified: Regular, Declining, Low and Selective service use. Regular service use was the most common service use pattern, although less than half the children fit this pattern. Children in the Regular service use group had the highest service use and the lowest magnitude of cumulative risks, relative to children in the other groups. The finding that lower levels of universal health and education service use was associated with higher levels of cumulative risks is consistent with studies that have reported lower participation in universal child health checks [17, 18] and Early Childhood Education and Care [20, 27] for more disadvantaged population groups, compared to less disadvantaged population groups.

Parents and caregivers are the primary agents for seeking and using services for their young children [12, 60]. While this study did not address the reasons why some families use universal services less than others, the association between lower service use and higher cumulative risks suggests that complex risk circumstances play a role in lower service use. This finding lends support to the view that, "Grounding an early childhood system of care in universal eligibility does not mean, however, that all families have similar risk for poor child outcomes or that all families have equal needs for services." [25, p. 115].

Australian early childhood universal health and education policy frameworks [30, 47] are grounded in a bioecological model of child development [61]. While these policy frameworks are sector-specific, both health and education policy frameworks explicitly recognise that children's health, development and learning are intrinsically linked and influenced by a common set of inter-related risk and protective factors [30, 47]. These frameworks recognise that tackling the social determinants of health and education inequalities is beyond the remit of any one sector and requires a coordinated, cross-sectoral approach to service provision [5, 15, 16].

Low and Declining service use patterns, adjusted for cumulative risks, were associated with increased odds of developmental vulnerability in the first year of full-time school. Regular use of universal health and education services from birth through Kindergarten was protective in reducing the odds of developmental vulnerability in the first year of full-time school, although children with multiple risk circumstances were less likely to use services regularly [62].

The findings suggest that the inverse care law operates across different types of universal early childhood services. The associations between higher levels of cumulative risks and lower uptake of services over time is likely to translate to cumulative missed developmental opportunities and widening inequalities in child development outcomes over time [18, 63]. While the associations between cumulative risk exposures and service use patterns are not causal, the findings draw attention to population groups who may benefit from outreach strategies to facilitate access to universal services [64]. This study provides an example of how cross-sectoral data sharing could support cross-sectoral service planning for a coordinated proportionate universal early childhood service system.

Future research

Further insights into universal early childhood use would be gained from linkage of data records that include measures of the intensity, timing and duration of service use.

Limitations and strengths

A limitation of this study is that there was no gold-standard external dataset defining true match status that could be used to compare to the research data set [65, 66]. However, the close concordance between the Australian Early Development Census National Report 2015 [35], and the study cohort, suggests that bias due to linkage errors did not disproportionately lead to an underestimate of the service needs of more disadvantaged population groups. The study was limited to universal services provided by government departments and did not include services provided by the non-government, not-for-profit, and for-profit sectors. The study only used single records of attendance at CHAs and did not include use of the CHaPS for purposes other than CHAs. The service use measure comprised a single record of a child's service use (yes/no) and did not capture important dimensions such as the intensity, timing and duration of service use. Nevertheless, harmonizing records of 10 child health and early education service events across the first four years of childhood into patterns of service use did reveal important differences in the uptake of early childhood services by groups of children with different levels of cumulative risk exposures. Latent class analysis is a data-driven approach to identifying patterns of service use that carries the risk of the results being sample-dependent. The use of a whole population sampling frame and use of administrative service records reduced the risk of selection bias and recall bias from the records of service events.

Conclusion

This study provides a whole population view of the differential use of universal services and the complex risk circumstances that influence service use. The association between patterns of multiple risk and service use points to barriers to service use, and the varying level of developmental vulnerability within each service use group draws attention to children who may benefit from higher sustained participation in core health and education services across the whole of early childhood. Universal services have an important role in identifying and referring children for specialist and targeted services, so the higher the participation in universal services, the greater the opportunity for services to monitor and respond to children's developmental needs. There is a great potential for the health and education sectors to share their service data and specialist expertise, and develop inter-agency strategies to better understand their service populations and to support the participation of all children in coordinated service pathways.

Acknowledgements

We acknowledge the partnership of the Tasmanian Department of Education, Department of Health and Department of Premier and Cabinet to conduct this study. We thank the data custodians from the Tasmanian Department of Education, Department of Health and Tasmanian Registry of Births, Deaths and Marriages who provided data for this study. The findings and views reported are those of the authors and should not be attributed to the Tasmanian Government Departments involved in the research. This study uses data from the Australian Early Development Census (AEDC). The AEDC is funded by the Australian Government Department of Education and Training. The findings and views reported are those of the authors and should not be attributed to the Department or the Australian Government. We thank the staff at the Tasmanian Data Linkage Unit for undertaking the linkage of the data-sets provided by the data custodians.

Statement on conflicts of interest

The authors declare they have no conflicts of interest.

Ethics statement

Approval to conduct this study was obtained from the Tasmanian Health and Medical Research Ethics Committee (H0016203).

Funding statement

This study was supported by a Partnership Project grant from the National Health and Medical Research Council Australia (1115891) and the Tasmanian Department of Education, Department of Health and Department of Premier and Cabinet. Catherine Taylor, Stephen Zubrick, Daniel Christensen and Joel Stafford were supported by the Australian Research Council Centre of Excellence for Children and Families over the Life Course (CE140100027). The funders had no role in the study design, analysis, decision to publish, or preparation of the manuscript.

Availability of data

The linked administrative data are owned by the government departments who approved the linkage and use of the data for this study. Use of the study data is restricted to named researchers. The current Human Research Ethics Committee approval was obtained for public sharing and presentation of data on group level only, meaning the data used in this study cannot be shared by the authors. Collaborative research may be conducted according to the ethical requirements and relevant privacy legislations. Potential collaborators should contact authors CT or AV with their expression of interest. The steps involved in seeking permission for linkage and use of the data used in this study are the same for all researchers.

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Supplementary Appendix A: Distribution of developmental vulnerability on one or more AEDC domains (DV1) and individual risk factors for children with observed and imputed data

	Number missing	Complete cases	Analytic sample ($n = 5,440 \times 25$)	Imputation only sample
AEDC Domain Category	**n**	%	%	%
Developmentally vulnerable on one or more AEDC domains (DV1)	228[1]	20.9	20.9	–
Risk factors				
Child				
Low birthweight (less than 2500 grams)	1	6.1%	6.1%	0.0%
Low gestational age (less than 37 completed weeks)	0	8.2%	8.2%	–
Multiple birth	0	2.7%	2.7%	–
Maternal				
Teenage mother at birth of child (less than 20 years)	0	5.9%	5.9%	–
Mother Indigenous	0	4.7%	4.7%	–
Three or more previous pregnancies	0	26.2%	26.2%	–
Smoking in pregnancy	0	24.9%	24.9%	–
Alcohol use in pregnancy	71	11.2%	11.2%	11.6%
Main carer education less than Year 11	1354	33.2%	33.2%	32.9%
Family				
Language other than English spoken at home by the child	0	1.9%	1.9%	–
Index of Relative Socio-economic Disadvantage (IRSD) Quintile 1 (Most Disadvantaged)	2	24.9%	24.9%	14.0%

[1]228 cases had missing AEDC domain categories, of which 221 were children with special needs. AEDC domain categories (DV1) were not imputed for children with missing AEDC domain categories.

Supplementary Appendix B: Statistical criteria for latent class models with 2-6 latent classes

Number of classes	A-BIC	Entropy
2	1520.45	**0.81**
3	1191.44	0.70
4	994.25	0.67
5	**992.47**	0.67
6	1016.09	0.68

Supplementary Appendix C: The distribution of individual and cumulative risk factors by service use group

	Regular service use group (46%)	**Declining service use group (24%)**	**Low service use group (18%)**	**Selective service use group (12%)**	**Population average service use**
Low birthweight	4.8%	7.5%	8.6%	5.0%	6.1%
Low gestational age	7.4%	8.5%	9.3%	8.9%	8.2%
Multiple birth	2.7%	4.2%	1.2%	2.4%	2.7%
Teenage mother at birth of child	5.1%	7.1%	7.4%	4.0%	5.9%
Indigenous mother	4.3%	4.6%	6.3%	4.3%	4.7%
Three or more previous pregnancies	18.9%	31.7%	38.4%	24.5%	26.2%
Smoking in pregnancy	17.2%	29.0%	40.1%	22.7%	24.9%
Alcohol use in pregnancy	10.0%	11.4%	13.5%	11.6%	11.2%
Main carer education less than year 11	29.2%	35.9%	41.9%	29.5%	33.2%
Language other than English spoken at home by the child	1.9%	1.4%	2.1%	2.8%	1.9%
Index of Relative Socio-Economic Disadvantage quintile 1 (most disadvantaged)	21.3%	25.7%	33.9%	23.6%	24.9%
0 risks	33.5%	24.3%	14.8%	29.8%	27.4%
1 risk	32.4%	26.1%	24.4%	30.4%	29.2%
2 risks	20.0%	23.5%	25.7%	20.9%	22.0%
3 risks	8.6%	15.8%	20.1%	11.6%	12.8%
4 risks	4.0%	6.5%	9.9%	4.9%	5.8%
5 risks	1.0%	2.9%	3.6%	1.8%	2.0%
6 risks	0.6%	0.7%	1.5%	0.5%	0.8%
7 risks	0.0%	0.0%	0.0%	0.1%	0.0%
8 risks	-	0.2%	-	-	0.0%