Chronic Illness and Developmental Vulnerability at School Entry

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abstract

OBJECTIVE: This study examined the association between chronic illness and school readiness, by using linked administrative population data.

METHODS: The sample included children born in 2003–2004 who were residing in Western Australia in 2009 and had a complete Australian Early Development Census record (N = 22 890). Health and demographic information was also analyzed for 19 227 mothers and 19 030 fathers. The impact of child chronic illness on 5 developmental domains (social, emotional, language, cognitive, and physical) at school entry was analyzed. Analyses examined the association between child developmental outcomes and chronic illness generally, single or multiple chronic illness diagnosis, and diagnosis type. Logistic regression models estimated odds ratios for each outcome, adjusted for child, parent, and community sociodemographic variables.

RESULTS: In the adjusted models, children with a chronic illness had an increased risk of being classified as developmentally vulnerable on all domains, compared with children without a chronic illness (20%–35% increase in risk). There was no increased risk for children with multiple chronic illness diagnoses over those with a single diagnosis (all Ps > .05). There was no evidence of a disease-specific effect driving this risk.

CONCLUSIONS: Regardless of the number or type of conditions, chronic illness in young children is a risk factor for reduced school readiness. These effects were seen for health conditions not traditionally considered detrimental to school readiness, such as chronic otitis media. Thus, the implications of a broader range of chronic health conditions in early childhood on school readiness need to be considered.

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WHAT'S KNOWN ON THIS SUBJECT: Chronic illness in childhood is associated with lower academic achievement. Only a few studies have examined the impact of ill health on children's readiness for school. These studies have used informant-reported general health ratings, which can be subject to bias.

WHAT THIS STUDY ADDS: We used clinical diagnosis information to examine the association between chronic illness and school readiness. We found that chronic illness experienced in early childhood was associated with increased risk of vulnerability across a range of developmental domains at school entry.

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Chronic illness is a term for physical health conditions that are prolonged in duration, difficult to treat, and associated with impairment or disability.[1] If experienced in early childhood, chronic illness has the potential to profoundly influence a child's developmental trajectory. Early childhood is a period of rapid growth in cognitive, linguistic, emotional, social, and behavioral capacities, which form the foundation for future academic success.[2] Children who lack a strong foundation in these abilities at school entry have lower academic trajectories than peers who have higher levels of school readiness.[3] Therefore, if chronic illness interrupts the development of the skills necessary for classroom adaptation and academic success, the effects may be long-lasting, persisting even after the child's health has recovered.[4]

Previous research examining the relationship between academic outcomes and child health has demonstrated that children and adolescents with chronic illnesses have lower achievement trajectories compared with their healthy peers, because of factors such as increased school absences and greater disengagement from school.[5,6] However, there is little evidence regarding the impact of poor health on the child at the start of school, when school absence and disengagement are unlikely to be implicated. Of the handful of studies available, children with special health care needs are found to be at risk for poorer psychosocial and cognitive outcomes compared with healthy peers.[4,7–9] This suggests that ill health in early childhood may influence the development of the skills that underlie academic success, placing children at risk for academic failure.[4,8] To minimize the impact of poor health on achievement trajectories, intervention for chronically ill children should therefore start early. However, the number of children with enduring medical conditions far outstrips the number of children receiving early intervention (EI) services.[7] This is due to a traditional approach to determining EI eligibility on the basis of specific diagnosis lists, which do not capture the full range of chronic conditions.[7,10] However, evidence reveals that chronic illnesses share important commonalities in how they impact the lives of the people affected, regardless of type or severity,[11] leading some to argue that this approach is outdated.[10] Our study takes a noncategorical approach to defining chronic illness to establish whether chronic illness in early childhood is associated with increased risk of developmental vulnerability at school entry.

Previous research on the association between chronic illness and academic outcomes has mostly been on the basis of either specific pediatric samples,[12–14] or used informant reports of health status.[4,7–9] Although providing important findings, these 2 designs have limitations in terms of the generalizability of results, and potential reporting bias, respectively. The current study adds meaningfully to this past research by using linked administrative population data, which enables identification of children with chronic illness across multiple diagnoses, rather than targeting specific disease groups. This study also uses diagnostic health information coded to professional standards, thus minimizing reporting bias. Importantly, with evidence that the risk of developmental vulnerability increases with each additional diagnosis,[15] administrative data also allow for the identification of children who have multiple chronic conditions. We hypothesize that chronic illness experienced between birth and age 5 years will be associated with increased risk of vulnerability across developmental domains. Further, we expect that having 2 or more chronic illnesses will elevate this risk compared with a single diagnosis. We will also examine whether the relationship between chronic illness and school readiness is disease-specific or generalized.

METHODS

Ethics Approval

Ethics approval for this study was granted by the Western Australian (WA) Department of Health Human Research Ethics Committee, the University of Western Australia Human Research Ethics Committee, and the WA Aboriginal Health Ethics Committee.

Data Sources

This study used anonymized administrative data merged across the WA Department of Health, the Commonwealth Department of Education, and the WA Register of Developmental Anomalies. Data sets were linked by the WA Data Linkage Branch by matching identifiers common to the sets of records (eg, name, address, etc).[16] Only deidentified records were provided to the researchers.

Study Population

The study included WA children born in 2003–2004 with a 2009 Australian Early Development Census (AEDC) record (N = 24 340). Children were excluded from the study if they (1) had missing AEDC domain scores (n = 382), (2) were from a multiple birth, in which case 1 child from each twin or triplet set was randomly selected (excluded n = 274), (3) were identified by the teacher as "special needs" in the AEDC data set (n = 753), or (4) had a diagnosis of developmental disorder (eg, autism) or cerebral palsy (n = 41) in the health or WA Register of Developmental Anomalies data sets. Special needs children have a diagnosed disability (physical,

TABLE 1 Description of Domains Assessed on the AEDC

Domain	Areas Assessed
Physical health and wellbeing	Physical readiness for school day (eg, dressed appropriately, fed)
	Physical independence
	Gross and fine motor skills
Social competence	Overall social competence
	Responsibility and respect
	Approaches to learning (eg, completion of work, following instructions, adaptability)
	Readiness to explore new things
Emotional maturity	Prosocial and helping behavior
	Anxious and fearful behavior
	Aggressive behavior
	Hyperactivity and inattention
Language and cognitive skills	Interest in literacy/numeracy and memory
	Basic literacy and advanced literacy
	Basic numeracy
Communication skills and general knowledge	Communication skills and general knowledge (eg, story-telling, imaginative play, articulation, understanding of others)

intellectual) and receive special assistance in school. AEDC domain scores are not calculated for these children because they have already been identified as having substantial developmental needs. Children with a developmental disorder or cerebral palsy were likewise excluded to limit the potential for confounding school readiness outcomes with preexisting developmental conditions.

The final study sample consisted of 22 890 children (mean age, 5.5 years; SD = 0.29; 49.3% girls; 6.2% Aboriginal), for whom health and demographic information was available for 84.0% of mothers (N = 19 227) and 83.1% of fathers (N = 19 030).

Outcome Measure

Children's developmental outcomes were assessed by using data from the AEDC, which is based on the Canadian Early Development Instrument,[17] and is a school readiness measure that is completed nationally every 3 years by teachers on children in their first year of formal schooling (in WA, the year before grade 1). Teachers complete 104 checklist items for each child, from which a score (from 0 to 10) is calculated for each of 5 developmental domains (Table 1). The method of calculating domain scores is the intellectual property of McMaster University in Canada. AEDC domain scores are analyzed at the national level and classified into percentiles, with cutoffs on the basis of the data collected in that year. Children who score in the bottom 10% of a domain are considered "developmentally vulnerable" on that domain; those in the bottom 10% to 25% as "at risk"; and those in the top 75% as "on track." For this study, these 3 categories were collapsed into 2 ("vulnerable/at risk" and on track) to capture established and emerging developmental vulnerability.

Chronic Illness Measure

The list of chronic illnesses included in this study was adapted from multiple sources, with a focus on physical health: the chronic illness list developed by Feudtner et al[18]; the list of childhood diseases from the National Health Interview Survey checklist as adapted by Newacheck et al[19]; and the list of conditions contributing to 80% of the disease burden in Australia.[20]

Diagnoses of chronic illness were obtained from the Emergency Department and Hospital Morbidity databases, which contain information on episodes of care for public and private hospital admissions in WA. In these data sets, diagnoses are recorded by using the *International Classification of Diseases, Tenth Edition, Australian Modification* (ICD-10-AM)[21] coding (see Supplemental Tables 7 and 8 for ICD-10-AM codes used in this study). Cancer diagnoses were obtained from the WA Cancer Registry.

Children were identified as having a chronic illness if they had at least 1 record of a diagnosed chronic condition in any of the 3 data sets during the study period (from birth to the end of 2009). Diagnosis was coded dichotomously, classified as absent (no record of an ICD-10-AM chronic illness code) or present (at least 1 ICD-10-AM chronic illness code). Additionally, if a child had only 1 chronic illness diagnosis in the study period, they were considered to have a single diagnosis, regardless of the number of admissions they had for that condition. If a child had 2 or more different chronic illness diagnoses in the study period, they were considered to have multiple diagnoses.

Control Variables

Because health and developmental outcomes are strongly linked to socioeconomic status,[22] child, parent, and community sociodemographic characteristics were included as control variables (Table 2). Variables were selected on the basis of findings of previous studies documenting

TABLE 2 Sociodemographic Characteristics of the Study Cohort

Characteristics	Whole Cohort, % (*N* = 22 890)	Child Chronic Illness, % (*n* =2879)	Child No Chronic Illness, % (*n* = 20 011)
Child's gender			
Girl	49.3	42.1	50.3
Boy	50.7	57.9	49.7
Ethnicity			
Aboriginal/Torres Strait Islander	6.1	9.8	5.6
Other[a]	93.9	90.2	94.4
Child speaks ESL			
No[a]	90.8	91.9	90.7
Yes	9.2	8.1	9.3
Child's mother has a chronic illness			
Yes	13.3	17.4	12.8
No[a]	86.7	82.6	87.2
Child's father has a chronic illness			
Yes	7.0	8.5	6.8
No[a]	93.0	91.5	93.2
Mother's marital status at time of cohort member's birth			
Single/never married	6.2	9.1	5.8
Divorced/widowed	1.0	1.2	0.9
Married[a]	76.3	80.7	75.7
Missing	16.5	9.0	17.6
Mother's age at time of cohort member's birth, y			
<20	4.5	5.8	4.3
20–29	36.4	41.8	35.6
30–39[a]	40.5	42.0	40.4
40+	2.5	2.1	2.5
Missing	16.1	8.3	17.2
Father's age at time of cohort member's birth, y			
<20	1.6	1.9	1.5
20–29	25.3	30.0	24.6
30–39[a]	44.4	45.7	44.2
40+	9.3	8.6	9.5
Missing	19.4	13.8	20.2
Local community remoteness index			
Major cities[a]	66.0	69.4	65.5
Regional	24.3	21.4	24.7
Remote	9.7	9.2	9.8
Local community IRSD			
1 (Most disadvantaged)	12.2	13.8	11.9
2	19.8	20.1	19.8
3	19.2	20.2	19.0
4	16.7	17.6	16.6
5 (Least disadvantaged)[a]	32.1	28.3	32.7

[a] Reference group for logistic regressions.

an association with developmental outcomes of children.[23–26]

Parent age and mother's marital status (at the time of the child's birth) were obtained from the Midwives Notification System and Birth Registrations. Parental chronic illness was also included as a control variable to account for intergenerational health disadvantage. Parental chronic illness was determined by the same method as child chronic illness and was also coded as a dichotomous variable (illness present or absent).

Child- and community-level control variables were obtained from the AEDC data set. Teachers identified if children spoke English as a second language (ESL). Local community remoteness and socioeconomic indices were determined by the Australian Standard Geographical Classification[27] and Index of Relative Socioeconomic Disadvantage[28] (IRSD), respectively, calculated for the child's home address at the time of AEDC completion. The Australian Standard Geographical Classification classifies a geographical area as metropolitan, inner/outer regional, or remote/very remote, on the basis of the access to goods, services, and community resources in that area. Due to smaller cohort numbers outside metropolitan areas, these 5 variables were collapsed into 3 (metropolitan, regional, and remote). The IRSD is derived from census information that reflects

TABLE 3 Prevalence of Different Chronic Illness Diagnoses

Diagnosis	Prevalence, *n* (%)
Chronic otitis media	2038 (71)
Chronic respiratory disease	764 (27)
Epilepsy	86 (3)
Anemia	80 (3)
Musculoskeletal disorders	41 (1)
Cardiovascular disease	39 (1)
Cancer	22 (<1)
Diabetes	14 (<1)
Malnutrition	11 (<1)
Obesity	7 (<1)
Chronic renal disease	5 (<1)
Cystic fibrosis	5 (<1)
Chronic liver disease	1 (<1)

area-level disadvantage such as low income, low educational attainment, and high unemployment. Local communities are given a score from 1 (most disadvantaged) to 5 (least disadvantaged).

Statistical Analysis

Logistic regression models were fitted with maximum likelihood estimation by using SAS version 9.3 for Windows (SAS Institute, Inc, Cary, NC).[29] This method modeled the odds of being classified as vulnerable/at-risk on each of the 5 AEDC domains as an outcome of chronic illness diagnosis. All control variables were entered into the models simultaneously, with the category representing lower risk on each variable coded as the reference group (Table 2). Unadjusted and adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were estimated for each AEDC domain.

Inspection of frequencies revealed that data were not missing at random, with Aboriginal children and children with ESL more likely to have missing data. To account for any potential bias missing data may be introducing to the models, missingness was included as an additional category in all regression models. This method was chosen over excluding cases with missing values because this would have excluded a large proportion of the target population. Adjusted models were also run excluding cases with missing information (n = 4504). The overall pattern of results was the same; however, ORs were slightly inflated. Therefore, the models presented in this article are more conservative models.

RESULTS

A total of 2879 (12.6%) children had a diagnosed chronic illness. Of these, 2667 (92.6%) had 1 diagnosis in the study period, and 212 (7.4%) had 2 or more diagnoses. Chronic otitis media was the most prevalent diagnosis, followed by chronic respiratory disease, and epilepsy (Table 3).

In the adjusted models, ORs were adjusted for the effects of the sociodemographic variables listed in Table 2. Holm's P value correction was applied to account for multiple hypothesis testing.[30,31] Models were initially run separately by gender; however, ORs were largely equivalent for all AEDC domains (maximum difference between ORs for girls and boys was 0.1), so results were combined.

In the unadjusted models, chronic illness was associated with an increased risk of developmental vulnerability across all domains (Table 4). These effects were attenuated, but still evident, in the adjusted models. Children were ~20% to 35% more likely to be classified as vulnerable/at-risk on all AEDC domains if they had a chronic illness, compared with their well peers.

To examine whether there was an elevated risk for children with multiple chronic illnesses, analyses were run to determine the odds of being classified as vulnerable/at-risk for children with a single or multiple diagnosis/es, compared with children with no diagnosis. Table 5 presents the fully adjusted models. Children with any single chronic illness diagnosis were at increased risk of developmental vulnerability on all AEDC domains compared with children without a diagnosis, with a 17% to 34% increase in risk. Children with 2 or more diagnoses during the study period were also more likely to be classified as vulnerable/at-risk on all AEDC domains, with a 53% to 85% increase in risk. We then modeled the risk associated

TABLE 4 Unadjusted and Fully Adjusted Odds of Being Classified as Developmentally Vulnerable/At-Risk on the AEDC as an Outcome of Child Chronic Illness Diagnosis

	Unadjusted			Adjusted[a]		
AEDC Domain	OR	95% CI	P[b]	OR	95% CI	P[b]
Physical wellbeing	1.43	1.31–1.56	.001	1.34	1.22–1.46	.001
Social competence	1.44	1.32–1.57	.001	1.36	1.25–1.49	.001
Emotional maturity	1.40	1.29–1.53	.001	1.33	1.22–1.45	.001
Communication skills and general knowledge	1.33	1.22–1.46	.001	1.30	1.18–1.42	.001
Language and cognitive skills	1.27	1.17–1.37	.001	1.19	1.09–1.30	.001

[a] Adjusted for parental chronic illness; child ethnicity; parent age; mother's marital status; child's ESL status; and local community socioeconomic disadvantage and remoteness indices.
[b] Adjusted P values at α = .05 after Holm's correction applied.

TABLE 5 Fully Adjusted Odds of Being Classified as Developmentally Vulnerable/At-Risk on the AEDC as an Outcome of Single or Multiple Chronic Illness Diagnosis

	Single Versus No Diagnosis[a]			Multiple Versus No Diagnosis			Single Versus Multiple Diagnoses		
AEDC Domain	OR	95% CI	*P*[b]	OR	95% CI	*P*[b]	OR	95% CI	*P*[b]
Physical wellbeing	1.32	1.20–1.45	.001	1.61	1.20–2.16	.001	0.82	0.61–1.11	.54
Social competence	1.34	1.22–1.47	.001	1.65	1.23–2.21	.003	0.81	0.60–1.10	.44
Emotional maturity	1.32	1.20–1.44	.001	1.53	1.15–2.05	.005	0.86	0.64–1.16	.54
Communication skills and general knowledge	1.26	1.14–1.38	.001	1.85	1.38–2.49	.006	0.68	0.50–0.92	.08
Language and cognitive skills	1.17	1.07–1.27	.001	1.54	1.16–2.05	.006	0.75	0.56–1.01	.28

[a] Adjusted for parental chronic illness; child ethnicity; parent age; mother's marital status; child's ESL status; and local community socioeconomic disadvantage and remoteness indices.
[b] Adjusted *P* values at $\alpha = .05$ after Holm's correction applied.

TABLE 6 Fully Adjusted Odds of Being Classified as Developmentally Vulnerable/At-Risk on the AEDC as an Outcome of Child Chronic Illness Diagnosis

	Chronic Otitis Media[a]			Chronic Respiratory Disease			Epilepsy		
AEDC Domain	OR	95% CI	*P*[b]	OR	95% CI	*P*[b]	OR	95% CI	*P*[b]
Physical wellbeing	1.30	1.16–1.45	.001	1.37	1.14–1.64	.001	1.11	0.62–1.98	.742
Social competence	1.35	1.21–1.50	.001	1.45	1.21–1.73	.003	0.79	0.42–1.47	.443
Emotional maturity	1.34	1.20–1.49	.001	1.30	1.09–1.56	.010	1.00	0.57–1.77	.998
Communication skills and general knowledge	1.28	1.14–1.43	.001	1.30	1.08–1.57	.011	1.09	0.61–1.96	.776
Language and cognitive skills	1.15	1.04–1.28	.007	1.24	1.05–1.47	.014	0.85	0.49–1.48	.564

[a] Adjusted for parental chronic illness; child ethnicity; parent age; mother's marital status; child's ESL status; and local community socioeconomic disadvantage and remoteness indices.
[b] Adjusted *P* values at $\alpha = .05$ after Holm's correction applied.

with multiple diagnoses compared with single diagnoses, with single diagnosis as the reference group (Table 5). This did not represent a statistically significant difference (all *P*s > .05).

Follow-up analyses examined whether there were disease-specific risks driving the effect on AEDC scores (Table 6). These analyses estimated the odds of being classified as vulnerable/at-risk on the AEDC for children with a single diagnosis of any 1 of the 3 most prevalent conditions (chronic otitis media, chronic respiratory disease, and epilepsy), compared with children without a chronic illness diagnosis. An increase in risk of developmental vulnerability was seen on all domains for children with a single diagnosis of otitis media (*n* = 1859; 15%–35% increase) and respiratory disease (*n* = 618; 24%–45% increase); however, there was no significant increase in risk for children with a diagnosis of epilepsy (*n* = 63; all *P*s > .05). For otitis media and respiratory disease, overlapping CIs indicated similarity of effect.

DISCUSSION

Our study used linked population-level administrative data to examine the association between chronic illness and school readiness. As expected, children with chronic illness were at increased risk of being classified as vulnerable/at-risk on all developmental domains, compared with children without a chronic illness, even after controlling for sociodemographic characteristics. This indicates that chronically poor health in early childhood is a risk for school readiness, over and above the disadvantage conferred by socioeconomic factors. This increased risk was particularly evident for social and emotional capacities. Social and emotional vulnerability in preschoolers with chronic illness has been previously documented,[15,32] with the suggestion that children with poor health are more likely to be submissive and excluded from social activities[33] and have low self-esteem.[34] School-based programs targeted at enhancing social and emotional abilities have been shown to lead to improvements in behavioral, social, and academic outcomes.[35] This may therefore be an important focus of intervention for chronically ill children.

Previous research has suggested that the negative impact on development increases with each additional chronic condition[15]; however, our findings do not support this. Although children with multiple chronic illnesses had an increased risk of being classified as developmentally vulnerable, this was not significantly greater than the risk associated with having a single diagnosis. This suggests that the presence of just 1 chronic illness is enough to increase a child's risk for lower school readiness. Follow-up analyses also revealed that the risk associated with chronic illness was not disease-specific, with similar risk levels seen for both chronic otitis media and respiratory disease.

This finding is in line with previous research suggesting commonalities between chronic conditions in terms of the impact they can have on the lives of the sufferer.[11] Our results support previous findings that suggest that chronic illness, in general, can interrupt the development of the skills children need for emotional, social, and physical progress.[4,7–9]

There was no evidence of a significant association between epilepsy and developmental vulnerability in this study. This is contrary to previous research, which has revealed an increased prevalence of behavioral and cognitive problems in children with epilepsy compared with those without.[13,36] This may be because the majority of epilepsy diagnoses in our cohort were either generalized idiopathic epilepsy, which is suggested to be associated with more mild impairments of social and educational function compared with other forms of epilepsy,[37] or "epilepsy unspecified" (convulsions, fits, or seizures not otherwise specified), which may capture children with more transient symptoms. Given the large body of research demonstrating adverse outcomes for children with epilepsy, we would caution against concluding from the findings of this study that epilepsy is not associated with developmental vulnerability for children.

Our findings suggest there is a need to broaden the scope of health conditions eligible for additional support at school entry. For instance, the most prevalent diagnosis was chronic otitis media, a common childhood condition that is associated with delayed language development, reading and spelling difficulties, and auditory processing deficits.[38] Although recurrent ear infections may not be associated with significant limitations in daily activities, our study demonstrated that children with this condition are at increased risk of poor school readiness, even without having a more severe comorbid condition. We therefore echo the sentiments of others arguing for a move away from the diagnosis-based eligibility model for EI services.[7,9,10] A noncategorical view of chronic illness will inform the development of interventions applicable to children with chronic illness, broadly, which will be more relevant to a wider range of families than a disease-specific approach.[39] O'Connor et al[40] recently proposed that eligibility for EI services should be based on functioning rather than diagnosis. Our results support this approach, as they suggest that the impact of chronic illness is not disease-specific, and is pervasive across developmental domains. As such, multidisciplinary collaboration will be crucial in responding to the complex needs of these children.

One limitation of this study was the amount of missing parental information on sociodemographic variables. However, because missingness was included in the regression models, any bias created by missing information should be minimized. Also, it should be noted that hospital data may be subject to selection bias because there is usually a higher rate of hospital admissions among disadvantaged groups, due to issues of availability and affordability of primary health care services.[41] Lastly, because chronic illness was identified only from hospital data sets, it is possible that rates of chronic illness were underestimated, because in metropolitan areas, the majority of people will attend their primary care physician (and not a hospital) for management of chronic conditions.[42] The chronic illnesses identified in this study may therefore represent the more severe end of the spectrum. Future research should compare rates of chronic disease recorded in hospital admissions with those recorded in general practice.

CONCLUSIONS

The findings of this study support the notion that chronic illness experienced in early childhood can influence the development of competencies that are critical to academic success. Although the increase in risk was generally small, the fact that these results are being seen at school entry, are pervasive across domains, and are likely to be additive over the child's trajectory, suggests that EI is required to ensure that these children do not fall behind their peers as they progress through school.

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ABBREVIATIONS

AEDC: Australian Early Development Census
CI: confidence interval
EI: early intervention
ESL: English as a second language
ICD-10-AM: *International Classification of Diseases, Tenth Edition, Australian Modification*
IRSD: Index of Relative Socioeconomic Disadvantage
OR: odds ratio
WA: Western Australian

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