

**BEHAVIORAL ASPECTS OF DIABETES**

The impact of type 1 diabetes mellitus in childhood on academic performance: A matched population-based cohort study

Rebecca J. Mitchell¹ | Anne McMaugh² | Helen Woodhead^{3,4,5} |
 Reidar P. Lystad¹ | Yvonne Zurynski¹ | Tim Badgery-Parker¹ |
 Cate M. Cameron^{6,7} | Tien-Ming Hng^{8,9}

¹Australian Institute of Health Innovation, Faculty of Medicine, Health and Human Sciences, Macquarie University, Sydney, NSW, Australia

²The Macquarie School of Education, Macquarie University, Sydney, NSW, Australia

³School of Women's and Children's Health, Faculty of Medicine, University of New South Wales, Sydney, NSW, Australia

⁴Department of Paediatric Diabetes and Endocrinology, Royal North Shore Hospital, Sydney, NSW, Australia

⁵Department of Endocrinology and Diabetes, Sydney Children's Hospital, Sydney, NSW, Australia

⁶Jamieson Trauma Institute, Royal Brisbane & Women's Hospital, Metro North Hospital and Health Services District, Brisbane, QLD, Australia

⁷Centre for Healthcare Transformation, Australian Centre for Health Services Innovation, Queensland University of Technology, Brisbane, QLD, Australia

⁸Department of Diabetes and Endocrinology, Blacktown and Mount Druitt Hospital, Sydney, NSW, Australia

⁹School of Medicine, Western Sydney University, Sydney, NSW, Australia

Correspondence

Rebecca J. Mitchell, Australian Institute of Health Innovation, Macquarie University, Level 6, 75 Talavera Road, Macquarie University NSW 2109, Australia.
 Email: r.mitchell@mq.edu.au

Funding information

Macquarie University

Abstract

Background and Objective: The impact of type 1 diabetes mellitus (T1D) on academic performance is inconclusive. This study aims to compare scholastic performance and high-school completion in young people hospitalized with T1D compared to matched peers not hospitalized with diabetes.

Research Design: Retrospective case-comparison cohort study.

Method: A population-level matched case-comparison study of people aged ≤ 18 hospitalized with T1D during 2005–2018 in New South Wales, Australia using linked health-related and education records. The comparison cohort was matched on age, gender, and residential postcode. Generalized linear mixed modeling examined risk of school performance below the national minimum standard (NMS) and generalized linear regression examined risk of not completing high school for young people hospitalized with T1D compared to peers. Adjusted relative risks (ARR) were calculated.

Results: Young females and males hospitalized with T1D did not have a higher risk of not achieving the NMS compared to peers for numeracy (ARR: 1.19; 95%CI 0.77–1.84 and ARR: 0.74; 95%CI 0.46–1.19) or reading (ARR: 0.98; 95%CI 0.63–1.50 and ARR: 0.85; 95%CI 0.58–1.24), respectively. Young T1D hospitalized females had a higher risk of not completing year 11 (ARR: 1.73; 95%CI 1.19–2.53) or 12 (ARR: 1.65; 95%CI 1.17–2.33) compared to peers, while hospitalized T1D males did not.

Conclusions: There was no difference in academic performance in youth hospitalized with T1D compared to peers. Improved glucose control and T1D management may explain the absence of school performance decrements in students with T1D. However, females hospitalized with T1D had a higher risk of not completing high school. Potential associations of this increased risk, with attention to T1D and psycho-social management, should be investigated.

KEYWORDS

high-school completion, school performance, type 1 diabetes, young people

1 | INTRODUCTION

Type 1 diabetes mellitus (T1D) is one of the most common chronic health conditions experienced by young people.¹ Worldwide, there are an estimated 2.58 million young people aged ≤ 19 years with T1D,² with a further 132,000 young people diagnosed with T1D annually.³ In Australia, there are an estimated 6,500 children aged ≤ 14 years living with T1D.⁴ T1D can influence the lives of young people in a variety of ways, including by affecting their general health,^{1,5} family, peer and community interactions¹ and both their school performance^{2,6} and attendance.⁷

T1D can be challenging to manage and without metabolic control, young people may experience acute complications, such as hypoglycaemia or ketoacidosis,² or more long-term chronic complications, such as retinopathy, neuropathy, or nephropathy.¹ There is also evidence that some young people with T1D experience mild deficits in their cognitive, motor, or visuospatial skills.^{8–11} Less ideal glycaemic control leading to frequent hypoglycaemic or keto-acidotic episodes could affect neuropsychological development, and thus, cognitive performance, including attention and memory skills.^{12,13} Cognitive deficits have the potential to influence academic performance among young people with T1D.^{2,6}

There have been mixed findings on the impact of T1D on academic performance in young people.^{12,14–16} Systematic reviews and meta-analyses have identified that young people with T1D can experience some cognitive impairment.^{10,17,18} Two studies conducted in Sweden and Arizona have identified that young people with T1D have poor academic performance compared to their peers or siblings without T1D,^{11,19} while other studies conducted in Australia, Scotland, and Washington have all found no difference in academic performance compared to peers.^{14,15,20,21} Three studies have identified differences in academic performance between sub-groups of young people with T1D, depending on their level of metabolic control, with young people with better metabolic control performing better academically.^{12,14,15} As previous research has indicated mixed findings in relation to whether T1D has an adverse impact on academic performance, the authors hypothesises that there is a difference between the academic performance of young people with T1D compared to their matched peers. Specifically, this study aims to compare scholastic performance and high school completion in young people hospitalized with T1D compared to matched peers not hospitalized with diabetes.

2 | METHOD

This is a retrospective population-based, case-comparison cohort study of young people hospitalized with T1D aged ≤ 18 years in New South Wales (NSW), Australia using linked birth, health, education and mortality data collections from 1 January 2005 to 31 December 2018.²² Ethical approval and a waiver of consent was obtained from the NSW Population and Health Services Research Ethics Committee (2018HRE0904).

2.1 | Data sources

Health service use information was obtained from emergency department (ED) visit and hospital admission data collections. ED visits to public hospitals in NSW included information on arrival and departure dates, visit type, and provisional diagnosis. Hospital admissions were to public or private hospitals and contained information on patient demographics, diagnoses, separation type (e.g., hospital transfer, death), and clinical procedures. Information on mortality was obtained from the NSW Registry of Births, Deaths, and Marriages and young people who died during the study period were excluded from analyses (Supplementary Figure 1).

School performance and parental demographic information was obtained from the National Assessment Plan for Literacy and Numeracy (NAPLAN) assessments conducted annually in May at government, Catholic, and independent schools from 2008 to 2018. NAPLAN assessments were conducted for young people in primary school grade 3 (age 7–9 years) and 5 (age 9–11 years), and high-school grades 7 (age 11–13 years) and 9 (age 13–15 years), and included assessments in numeracy and reading. Each assessment score is translated into proficiency bands that indicate whether performance was above, at, or below the national minimum standard (NMS). Inability to achieve the NMS indicates that a young person will have difficulty making progress in school without assistance.²³ For each NAPLAN assessment, scores represent the same level of achievement over time.²⁴

A young person's attendance, absence, withdrawal (e.g., philosophical objections to testing, or religious beliefs) or exemption due to significant disability for the NAPLAN assessments was obtained (Supplementary Table 1). Young people exempt from sitting an assessment, due to a severe disability or language difficulties were rated as achieving below the NMS as per technical guidelines.²⁵

A young person was identified as having a language background other than English (LBOTE) if either they or their parents or guardians spoke a language other than English at home.²⁴ Where there were multiple records of the parents' level of education and occupation over time, the highest level of education and occupation of either parent was identified. Information on high-school completion at years 10 (15–16 years of age), 11 (17–18 years of age), and 12 (17–18 years of age) were obtained for each young person from the Record of School Achievement and the Higher School Certificate.

The Center for Health Record Linkage (CHeReL) randomly identified the population comparison group and linked the birth, health, education, and mortality records using probabilistic record linkage. Upper and lower probability cut-offs for a link were 0.75 and 0.25 and record groups with probabilities between the cut-offs were clerically reviewed.

2.2 | Case inclusion criteria

Cases included young people with a year of birth ≥ 1997 who were aged ≤ 18 years at their index hospitalization who had a principal or additional diagnosis of T1D in their principal diagnosis or up to

50 additional diagnosis classifications (International Classification of Diseases, 10th Revision, Australian Modification (ICD-10-AM: E10) during 1 January 2005 to 31 December 2018. Cases were included if both the numeracy and reading NAPLAN assessments in a school grade were completed by the young person.

2.3 | Comparison group criteria

The population-based comparison group included young people not hospitalized with any form of diabetes (ICD-10-AM: E10-E14) from 1 July 2001 to 31 December 2018. Comparison group members were randomly selected from NSW birth records matched 1:1 on age, gender, and residential postcode to their counterpart. The timeframe for selection of comparisons included a 3.5 year wash out period prior to the case selection timeframe to avoid the potential selection of comparisons who may have been hospitalized with any form of diabetes prior to the case criteria timeframe.

2.4 | Identification of chronic health conditions

Common chronic health conditions experienced by young people were identified from prior studies of pediatric comorbidities²⁶⁻²⁸ and were health conditions reasonably expected to last 12 months or need ongoing healthcare.²⁶ For this study, comorbidities were identified using diagnosis classifications from ICD-10-AM and a 3-year lookback period (to 1 January 2002) (Supplementary Table 2).

2.5 | Socioeconomic status and geographical location

The young person's postcode of residence was used to classify socioeconomic disadvantage into quintiles from most (i.e., 1) to least (i.e., 5) disadvantaged.²⁹ The Australian Statistical Geographical Standard (ASGS),³⁰ based on distance to service centers, was used to classify the residential postcode of the young person as either urban (i.e., major cities) or rural (i.e., inner and outer regional, remote, and very remote). The remoteness area of the school was obtained from the NAPLAN data collection and was categorized as major city, inner regional, outer regional, or remote.³⁰

2.6 | Data organization and analysis

Data analysis was conducted using SAS 9.4 (SAS Institute, Cary NC). All hospital episodes of care related to the same event were linked to form a period of care. Chi-square tests of independence and Wilcoxon Mann-Whitney tests were used to examine characteristics of young people hospitalized for T1D and their matched counterparts. The number of ED visits, hospitalisations, and hospital length of stay (LOS) before and during, and after, the index hospital admission were

identified for cases and their matched peers. The calculation of hospital LOS was cumulative and included hospital transfers.

To examine school performance, generalized linear regression using PROC GENMOD assessed the difference in proportions of performance below the NMS for each assessment at each school grade (i.e., 3, 5, 7, and 9) for young people hospitalized with T1D and their matched counterparts (Supplementary Table 3). Unadjusted and adjusted relative risks (ARR) and 95% confidence intervals (CIs) were calculated.

For the numeracy and reading assessments, each model was fitted using generalized estimating equations (GEE) with binomial distribution and a log function. Purposeful forward selection was used³¹ to sequentially add covariates to the models²² and significance was assessed using *p*-values (*p* < 0.05) to examine overall effect in the models. The final models examined predictors of performance below the NMS and included diabetes status (Y/N), gender, socioeconomic status, highest level of education for any parent (i.e., ≤Year 12; certificate I-IV, trade or diploma; bachelor or higher degree; or other), and highest level of occupation of any parent (i.e., senior manager/qualified professional; business manager/associate professional; trades/clerks/skilled office/sales and service; machine operators/hospitality/assistants/laborers; or not in paid work in last 12 months). Matching variables were included in each model to control for any possible confounding from the matching variables.³²

Generalized linear mixed modeling (GLMM) was conducted to perform multi-level modeling of school performance below the NMS for each of the numeracy and reading assessments for cases and their matched peer who had completed assessments in different school grades. For each NAPLAN assessment, PROC GLIMMIX was used with a binary distribution, log link function, and Kenward and Roger denominator degrees of freedom. The residual option of the random statement was used to model R-side covariance and data were analyzed to account for within student correlation in the longitudinal data and repeated measurements using an autoregressive covariance structure. Unadjusted RR and ARRs and 95% CIs were generated. The final models included: diabetes status (Y/N), gender, comorbidity status (Y/N), NAPLAN grade (i.e., 3, 5, 7, 9), school sector (i.e., government, Catholic, independent), LBOTE, socioeconomic status and highest level of education and occupation for any parent.

Factors associated with high-school completion at either year 10, 11, or 12 for cases compared to their matched peers were examined using generalized linear regression using PROC GENMOD. For each grade, a model was fitted using GEE with binomial distribution and a log function. ARR and 95% CIs were calculated. The final models examined predictors of not completing high school and included: diabetes status (Y/N), gender, comorbidity status (Y/N), LBOTE, socioeconomic status, highest level of education for any parent/guardian, and geographic location of residence.

3 | RESULTS

There were 833 young people hospitalized with T1D for whom a matched comparison was identified and who completed NAPLAN

TABLE 1 Demographic and healthcare use characteristics of young people hospitalized with type 1 diabetes mellitus and their matched comparison by grade, linked health, and school performance data NSW, 2005–2018

Characteristics	Grade 3 ^a			Grade 5 ^b			Grade 7 ^c			Grade 9 ^d		
	Case (n = 833)	Comparison (n = 833)	%	Case (n = 673)	Comparison (n = 673)	%	Case (n = 516)	Comparison (n = 516)	%	Case (n = 324)	Comparison (n = 324)	%
Gender												
Male	379	379	45.5	306	306	45.5	243	243	47.1	155	155	47.8
Female	454	454	54.5	367	367	54.5	273	273	52.9	169	169	52.2
Location of residence^e												
Urban	606	606	72.8	487	487	72.4	378	378	73.3	241	241	74.4
Rural	226	226	27.1	186	186	27.6	138	138	26.7	83	83	25.6
Socioeconomic status^e												
Most disadvantaged	164	164	19.7	132	132	19.6	94	94	18.2	53	53	16.4
2	187	187	22.5	151	151	22.4	112	112	21.7	66	66	20.4
3	190	190	22.8	157	157	23.3	129	129	25.0	78	78	24.1
4	87	87	10.4	64	64	9.5	49	49	9.5	33	33	10.2
Least disadvantaged	204	204	24.5	169	169	25.1	132	132	25.6	94	94	29.1
LBOTE^f												
Non-LBOTE	656	678	78.8	541	553	81.4	423	439	82.0	270	274	83.3
LBOTE	171	151	20.5	130	117	18.1	92	76	17.8	53	49	15.1
Health condition												
0	818	818	98.2	659	660	98.1	503	504	97.5	315	315	97.2
≥1	15	15	1.8	14	13	1.9	13	12	2.5	9	9	2.8
Parent highest level of education												
Year 11 or equivalent	52	63	6.2	46	60	8.9	34	52	10.1	23	29	9.0
Year 12 or equivalent	49	32	4.9	41	28	4.2	28	25	4.8	16	17	5.3
Certificate I–IV or trade	255	263	30.6	205	216	32.1	166	158	30.6	102	91	28.1
Advanced diploma/diploma	127	141	15.3	109	115	17.1	85	91	17.6	45	59	18.2
Bachelor degree or higher	319	300	38.3	261	242	36.0	196	183	35.5	134	121	37.4
Not stated/not known	31	34	3.7	11	12	1.8	7	7	1.4	4	7	2.2
Parent highest occupation												
Senior manager/qualified professional	275	261	33.0	236	217	32.2	181	175	33.9	125	119	36.7
Business management/associate professional	196	208	23.5	158	168	25.0	120	130	23.3	78	74	22.8
Trades, clerks, skilled office, sales and service	189	187	22.7	152	152	22.6	119	107	23.1	66	72	22.2

TABLE 1 (Continued)

Characteristics	Grade 3 ^a			Grade 5 ^b			Grade 7 ^c			Grade 9 ^d						
	Case (n = 833)		Comparison (n = 833)	Case (n = 673)		Comparison (n = 673)	Case (n = 516)		Comparison (n = 516)	Case (n = 324)		Comparison (n = 324)				
	n	%	n	%	n	%	n	%	n	%	n	%				
Machine operators, hospitality, assistants, laborers	98	11.8	101	12.1	79	11.7	81	12.0	56	10.9	65	12.6	35	10.8	35	10.8
Not in paid work in last 12 months	50	6.0	46	5.5	31	4.6	35	5.2	27	5.2	27	5.2	13	4.0	13	4.0
Not known	25	3.0	30	3.6	17	2.5	20	3.0	13	2.5	12	2.3	7	2.2	11	3.4
Health care use	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
ED visits	4.0	6.9	1.8	3.6	4.3	6.6	2.1	3.8	5.4	6.4	2.3	3.8	5.5	5.5	2.4	3.8
Hospital admissions	2.5	3.8	0.5	1.0	2.7	3.6	0.5	1.0	3.6	4.4	0.6	1.1	3.9	4.8	0.6	1.0
Hospital length of stay	5.6	9.9	1.5	4.0	6.2	9.8	1.5	3.8	8.5	12.3	1.5	3.6	9.3	13.1	1.4	3.2

Abbreviation: LBOTE, language background other than English.

^aGrade 3 chi-square test: LBOTE $p = 0.4$; health conditions; $p = 1.0$; parent highest level of education $p = 0.3$; parent highest occupation $p = 0.9$; and Wilcoxon Mann–Whitney tests: ED visits $p < 0.0001$; hospital admissions $p < 0.0001$; hospital length of stay $p < 0.0001$.

^bGrade 5 chi-square test: LBOTE $p = 0.6$; health conditions $p = 0.8$; parent highest level of education $p = 0.4$; parent highest occupation $p = 0.9$; and Wilcoxon Mann–Whitney tests: ED visits $p < 0.0001$; hospital admissions $p < 0.0001$; hospital length of stay $p < 0.0001$.

^cGrade 7 chi-square test: LBOTE (excluding not known) $p = 0.2$; health conditions $p = 0.8$; parent highest level of education $p = 0.4$; parent highest occupation $p = 0.9$; and Wilcoxon Mann–Whitney tests: ED visits $p < 0.0001$; hospital admissions $p < 0.0001$; hospital length of stay $p < 0.0001$.

^dGrade 9 chi-square test: LBOTE (excluding not known) $p = 0.7$; health conditions $p = 1.0$; parent highest level of education $p = 0.5$; parent highest occupation $p = 0.9$; and Wilcoxon Mann–Whitney tests: ED visits $p < 0.0001$; hospital admissions $p < 0.0001$; hospital length of stay $p < 0.0001$.

^eExcludes not known location of residence and socioeconomic status for 1 case and 1 comparison in grade 3.

^fLanguage background other than English and LBOTE was not known for 10 cases and 9 comparisons.

TABLE 2 School and NAPLAN assessment characteristics of young people hospitalized with type 1 diabetes mellitus and their matched comparison by grade, linked health, and school performance data NSW, 2005–2018

Characteristics	Grade 3 ^a				Grade 5 ^b				Grade 7 ^c				Grade 9 ^d			
	Case (n = 833)		Comparison (n = 833)		Case (n = 673)		Comparison (n = 673)		Case (n = 516)		Comparison (n = 516)		Case (n = 324)		Comparison (n = 324)	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
School sector																
Government	571	68.6	576	69.2	457	67.9	457	67.9	296	57.4	281	54.5	191	59.0	169	52.2
Catholic	174	20.9	168	20.2	145	21.6	134	19.9	125	24.2	136	26.4	82	25.3	89	27.5
Independent	87	10.4	89	10.7	70	10.4	82	12.2	94	18.2	99	19.2	51	15.7	66	20.4
Remoteness area of school																
Major city	599	71.9	574	68.9	479	71.2	465	69.1	371	71.9	365	70.7	234	72.2	229	70.7
Inner regional	181	21.7	203	24.4	151	22.4	170	25.3	118	22.9	121	23.5	70	21.6	80	24.7
Outer regional/ remote	52	6.2	56	6.7	42	6.2	38	5.7	26	5.0	30	5.8	20	6.2	15	4.6
NAPLAN assessment ^e																
Numeracy (below NMS)	32	3.8	33	4.0	18	2.7	27	4.0	16	3.1	17	3.3	7	2.2	3	0.9
Reading (below NMS)	28	3.4	32	3.8	34	5.1	40	5.9	18	3.5	17	3.3	10	3.1	15	4.6

^aGrade 3 chi-square test: school sector (excluding 1 home-schooled) $p = 0.9$; remoteness area of school (excluding 1 missing) $p = 0.4$; numeracy $p = 0.9$; reading $p = 0.6$.

^bGrade 5 chi-square test: school sector (excluding 1 home-schooled) $p = 0.5$; remoteness area of school (excluding 1 missing) $p = 0.5$. numeracy $p = 0.2$; reading $p = 0.5$.

^cGrade 7 chi-square test: school sector (excluding 1 home-schooled) $p = 0.6$; remoteness area of school (excluding 1 missing) $p = 0.8$. numeracy $p = 0.9$; reading $p = 0.9$.

^dGrade 9 chi-square test: school sector $p = 0.2$; remoteness area of school $p = 0.5$. numeracy $p = 0.2$; reading $p = 0.3$.

^eNAPLAN: National Assessment Plan for Literacy and Numeracy; NMS: National Minimum Standard.

TABLE 3 Multilevel model of type 1 diabetes mellitus associated with a below NMS NAPLAN assessment for young people with an index hospitalization for during 2005–2018 compared to a matched comparison, linked health and school performance data NSW

	Numeracy				Reading			
	RR ^a	95%CI	ARR ^b	95%CI	RR ^a	95%CI	ARR ^b	95%CI
All persons ^b	0.90	0.65–1.24	0.96	0.70–1.31	0.88	0.66–1.17	0.91	0.69–1.20
Male ^c	0.69	0.43–1.11	0.74	0.46–1.19	0.82	0.57–1.19	0.85	0.58–1.24
Female ^c	1.14	0.73–1.77	1.19	0.77–1.84	0.97	0.61–1.54	0.98	0.63–1.50

Abbreviations: ARR, adjusted relative risks; CI, confidence interval.

^aUnadjusted relative risk. Analyses exclude 1 (0.04%) case with missing socioeconomic status, 10 (0.4%) with missing LBOTE and 3 (0.1%) who were home schooled.

^bAdjusted for diabetes status, gender, NAPLAN grade, LBOTE, socioeconomic status, parental education and occupation, and school sector.

^cAdjusted for diabetes status, NAPLAN grade, LBOTE, socioeconomic status, parental education and occupation, and school sector.

assessments in Grade 3; 673 in Grade 5; 516 in Grade 7; and 324 in Grade 9 during 2015–2018. There were 843 young people with T1D hospitalized with a matched peer identified who could have completed year 10; 775 in year 11; and 682 in year 12 of high school.

Across the school grades 3–9, there was a higher proportion of females (between 52.2% and 54.5%) compared to males and a higher proportion of young people in urban areas (between 72.4% and 74.4%) compared to rural areas hospitalized with T1D. Most

young people ($\geq 79\%$) were from English-speaking households and almost all ($\geq 97\%$) had no other chronic comorbidities identified. There were no significant differences between parental education or occupation for young people with T1D and their matched peers in each school grade. Young people hospitalized with T1D had higher mean number of ED visits, hospital admissions, and hospital LOS than their matched counterparts in each school grade (Table 1).

TABLE 4 Analysis of characteristics associated with not completing high school for young people with an index hospitalisation with type 1 diabetes mellitus compared to a matched comparison by grade, linked health, and school performance data NSW, 2005–2018

No school completion	Year 10 <i>n</i> = 843 in each cohort			Year 11 <i>n</i> = 775 in each cohort			Year 12 <i>n</i> = 682 in each cohort		
	<i>n</i>	% ^a		<i>n</i>	% ^a		<i>n</i>	% ^a	
Case	23	2.7		136	17.6		164	21.1	
Comparison	17	2.0		104	13.4		126	18.5	
Gender	<i>n</i> ^b	ARR ^c	95%CI	<i>n</i> ^b	ARR ^d	95%CI	<i>n</i> ^b	ARR ^e	95%CI
All persons	23	1.29	0.68–2.42	136	1.31**	1.02–1.69	164	1.31**	1.04–1.65
Male	8	0.79	0.31–2.01	63	1.04	0.73–1.47	79	1.10	0.80–1.50
Female	15	2.00	0.80–4.97	73	1.73*	1.19–2.53	85	1.65*	1.17–2.33

Abbreviations: ARR, adjusted relative risks; CI, confidence interval.

^aPercent calculated for young people in case and comparison cohorts not completing the school grade.

^bNumber of students hospitalized with diabetes not completing the year.

^cYear 10 all person adjusted relative risk for diabetes status, gender, socioeconomic status (excluding 5 missing), and parental education. Both males and females adjusted for diabetes status, socioeconomic status, and parental education.

^dYear 11 all person adjusted relative risk for diabetes status, gender, LBOTE, socioeconomic status (excluding 4 missing), residential geographic location, and parental education. Males and females adjusted for diabetes status, LBOTE, socioeconomic status, and parental education.

^eYear 12 all person adjusted relative risk for diabetes status, gender, LBOTE, socioeconomic status (excluding 4 missing), and parental education. Males and females adjusted for diabetes status, LBOTE, socioeconomic status, and parental education.

p* < 0.004; *p* < 0.03.

Young people predominantly attended government schools in major cities and there were no significant differences by school sector or location of the school for young people hospitalized with T1D, compared to their matched counterparts, in each grade. The proportion of students hospitalized with T1D who did not achieve the NMS for their numeracy or reading assessment in grades 3–9, did not differ significantly from their matched peers (Table 2).

After adjustment for covariates, young females hospitalized with T1D did not have a higher risk of not achieving the NMS compared to matched peers on school assessments for numeracy (ARR: 1.19; 95% CI 0.77–1.84) or reading (ARR: 0.98; 95%CI 0.63–1.50). Young males hospitalized with T1D similarly had no higher risk of not achieving the NMS for numeracy (ARR: 0.74; 95%CI 0.46–1.19) or reading (ARR: 0.85; 95%CI 0.58–1.24), compared to their matched counterparts (Table 3).

Young females hospitalized with T1D showed no difference in completion of year 10, but had a higher risk for not completing year 11 (ARR: 1.73; 95%CI 1.19–2.53) or year 12 (ARR: 1.65; 95%CI 1.17–2.33) compared to their matched peers. Young males hospitalized with T1D had no higher risk for not completing high school in years 10, 11, or 12, compared to their matched counterparts (Table 4).

4 | DISCUSSION

This study found no association between young people hospitalized with T1D and the risk of not achieving minimum standards for numeracy and reading in standardized school-based assessments, compared to matched peers for young females or males not hospitalized with diabetes. It also found that young females with T1D had a higher risk of not completing year 11 or 12, but not year 10, compared to matched peers. However, it did not find a higher risk of not completing

high school for young males hospitalized with T1D, compared to their matched counterparts. This study has confirmed that academic performance is not adversely affected by T1D, although females with T1D were less likely to complete high school.

The impact of T1D on the lives and abilities of young people is complex and does not appear to be uniform. While T1D has been shown in previous research to negatively affect facets of academic skill development,¹¹ the current study found no discernible difference in academic performance compared to matched peers. Similar to the current study, comparisons of academic performance between young people with T1D and non-diabetic peers in Scotland¹⁴ and Denmark¹⁵ found no significant differences in performance. In addition, two studies conducted in Australia, one in Western Australia²⁰ and another in South Australia among grade 5 students,¹⁶ similarly found no differences in the academic performance of young people with T1D compared to non-diabetic peers.

Differences in the findings on the impact of T1D on academic performance may be explained by the fact that previous studies that found students with T1D had worse academic performance than peers, included student cohorts from the 1970s and 1980s¹⁹ or used subjective teacher ratings of performance, rather than standardized assessments.¹¹ The non-objective assessment of student performance may have resulted in biased reporting of academic performance. It is also likely that significant advances in treatment regimens and modalities, as well as the increased availability of diabetes insulin pump and continuous glucose monitoring (CGM) technologies, which have been associated with improved outcomes in severe hypoglycaemia³³ and diabetic ketoacidosis,¹³ as well as overall diabetes control,³⁴ have improved T1D outcomes²⁰ and subsequently reduced the potential for negative consequences of T1D on student academic performance.

One of the studies that identified decrements in academic performance for young people with T1D compared to healthy peers, did not

find consistent performance across each subject.¹⁹ This Swedish study examined performance in mathematics, Swedish, English and sports in young people with T1D compared to peers and found an increased likelihood of not passing, or receiving a lower mark, for mathematics and Swedish, but no significant difference in performance in sport or English for young people with T1D¹⁹ compared to peers. However, the research did identify that young people with T1D had a reduced likelihood of achieving a high mark (e.g., distinction) in sport or English, compared to peers.¹⁹ That consistent performance decrements for young people with T1D are not evident across school subjects illustrates the complexity of the impact of T1D on academic performance. It is also possible that annual standardized school assessments, such as NAPLAN, may not adequately capture everyday difficulties that could be experienced by young people with T1D in the school environment,^{1,16} and that more nuanced, frequent, and regular monitoring of academic performance is required.

The current study was unable to take into account age at onset of T1D and level of metabolic control (i.e., glycosylated hemoglobin A1c (HbA1c)). One prior study found that young people who had early onset of T1D (i.e., <7 years of age) had poorer school performance compared to young people with later onset T1D.¹⁹ There is evidence of structural changes in the brains of young people diagnosed with T1D at a younger age,³⁵ thought to be due to episodes of significant hypoglycaemia, and it is possible that a longer disease duration of T1D, because of early onset age, may be associated with difficulties with cognition, memory, and attention.³⁶ Yet other studies did not identify any impact of age of onset for T1D on academic achievement.^{11,12,15,21} It is probable that once an intensive treatment regimen has commenced for a young person, the age of onset could become less of an issue for academic performance,¹¹ particularly where insulin pump and integrated CGM technologies can ameliorate the incidence of profound hypo- and hyper-glycaemia.³³ However, most research-lacked information regarding adherence by young people with T1D to a treatment regimen.

In comparing academic performance on numeracy and literacy for sub-groups of young people with T1D, previous research found that young people who experienced metabolic control (i.e., HbA1c levels <8%) performed better academically than those with less ideal metabolic control (i.e., HbA1c levels >10%).¹² Similarly, research in Scotland¹⁴ identified that young people with T1D with better metabolic control performed better academically than students with poor metabolic control. Whereas, a study in Denmark¹⁵ found that young people with metabolic control performed worse on assessments of literacy and numeracy than students with poor metabolic control. The authors speculated that the negative association between metabolic control and school performance could be the result of the provision of increased learning support services to students with T1D.¹⁵

The current study found that young females hospitalized with T1D had a higher risk of not completing high school than matched peers. Similarly, Fletcher and Richards³⁷ identified that young people with T1D were 5% to 7% more likely to drop out of high school than their peers. Adolescent females with T1D experience more issues with metabolic control,³⁸ more distress,³⁹ and have a higher risk of

developing an eating disorder than young males.^{40,41} For females with T1D, transitioning from childhood to adolescence may have wider psychosocial implications that contribute to young females having higher risk of early school leaving. The additional psychological distress and a higher prevalence of eating disorders among young people with T1D⁴² attests to the need for regular psychological screening of young people with T1D.⁴³

Other studies did not find a similar association with T1D and high-school dropout. In Scotland, there was no increase in the proportion of young people with T1D leaving school before age 16 compared to peers.¹⁴ Likewise, in Finland there was no difference in young people with T1D leaving school at age 16 compared to peers, including no difference by sex,⁴⁴ nor in Sweden.¹⁹ However, in Sweden, once the age of onset of T1D was taken into account, children diagnosed with T1D before 2 years of age had a higher likelihood of dropping out of high school.¹⁹ The differences found between studies could relate to case identification criteria, with the current study only including young people hospitalized with T1D, therefore was more likely to include more poorly controlled cases. Other studies identified cases from clinical registers or from prescribed medications to identify any young person with T1D,⁴⁴ which could also include young people who had not been hospitalized with T1D.

Advances in treatment modalities,^{15,20} compared to some of the earlier studies of the impact of T1D on academic performance, better glycaemic control through improved diabetes management,^{11,20} such as using insulin pumps rather than insulin injection modalities,¹⁶ use of CGM technology, especially where CGM is linked to pump technology, and better communication and training regarding T1D management strategies, including with school staff^{1,16} are all likely to have contributed to obtaining the similar educational outcomes for young people with T1D compared to non-diabetic peers. Further support for students with T1D is being provided in Australia with the launch in 2020 of the national diabetes in schools program in Australia.⁴⁵ The program aims to provide information, training, and support for educators, families, and health professionals to better support young people with T1D.⁴⁵

Further research examining T1D and academic performance in Australia could link health and education performance data to primary care attendances, diabetes registry and pharmaceutical dispensing data, as this would allow confirmation of age at T1D diagnosis, diabetes management, and outcomes. Additional research is also required to further tease out the impact of recent versus latent T1D diagnosis on a young person's academic performance and also identify if there are any later health and social outcomes, including on employment opportunities.

This study's strengths were that it was a large population-level cohort study, linking health and standardized academic assessment records over a 13-year period and was able to adjust for key factors that may influence academic performance, such as socioeconomic status and parental education. However, the study had some limitations. The study only included young people who had been hospitalized with T1D, so did not include young people presenting solely to tertiary center diabetes outpatient departments, primary care or other health

professionals for treatment. Although, hospitalized young people with T1D were more likely to have less perfect diabetes control. There was no information in the hospitalization data regarding metabolic control (i.e. HbA1c levels, time in range on CGM or the proportion of time high, very high, or low), number of severe hypo/hyperglycaemic episodes, frequency of diabetic ketoacidosis, prescribed insulin doses/kg, age of T1D onset for the young person, or access to specialist care from endocrinologists. Only chronic health conditions relevant to a hospital admission are recorded in diagnosis classifications and it is likely that some comorbidities were not identified. This is particularly the case for the comparison cohort, where 68.6% had not been hospitalized, leaving no opportunity to identify comorbid conditions, despite the 3-year lookback period.

A small number of residential postcodes were not able to be provided to the authors and socioeconomic status for these records was not able to be identified. The recency of postcode of residence may vary between data collections, which may affect estimates of socioeconomic status. Data validity was not able to be assessed and it is possible that there could be some data misclassification in hospital or education records. Visits to private hospital EDs were not able to be accessed for this study. A higher proportion of young people with T1D were absent for NAPLAN assessments compared to their matched counterparts. The current study was not able to take into account school clustering and no information was available concerning any tutoring or supplementary education services that a young person may have received.

5 | CONCLUSION

There was no difference in the academic performance of either young females or males with T1D compared to matched peers. Better glucose control and awareness of strategies to manage T1D, including diabetes education programs for young people in schools, may explain the absence of school performance decrements for students with T1D. However, young females hospitalized with T1D did have a higher risk of leaving high school than their matched peers. Additional research is needed to explore psychological and social factors, as well as T1D control factors, that may contribute to this increased risk, and suggests the need for routine psychological screening as recommended in best practice guidelines.

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CONFLICT OF INTEREST

The authors declare they have no conflict of interest.

AUTHOR CONTRIBUTIONS

RM, CC, and AM were all involved in study concept and design. RM acquired and organized the data, conducted the analysis and wrote the first draft of the manuscript. TB-P provided statistical assistance for the GLMM analysis. All authors were involved in interpretation of data and critical revision of the manuscript.

PEER REVIEW

The peer review history for this article is available at <https://publons.com/publon/10.1111/pedi.13317>.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the NSW Health Department, NSW Department of Education, and NSW Education Standards Authority. Restrictions apply to the availability of these data, which were used under licence for the current study, so are not publicly available.

ORCID

Rebecca J. Mitchell  <https://orcid.org/0000-0003-1939-1761>

Anne McMaugh  <https://orcid.org/0000-0003-2988-0366>

Reidar P. Lystad  <https://orcid.org/0000-0003-0506-0902>

Yvonne Zurynski  <https://orcid.org/0000-0001-7744-8717>

Tim Badgery-Parker  <https://orcid.org/0000-0002-1275-1130>

Cate M. Cameron  <https://orcid.org/0000-0003-1476-5744>

Tien-Ming Hng  <https://orcid.org/0000-0001-6813-8813>

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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