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Educational attainment of children with self-limited epilepsy with CentroTemporal spikes (SELECTS), other epilepsies, and without epilepsy: A retrospective cohort study

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ABSTRACT

Background: Children with epilepsy may have poorer educational outcomes—this may not be true for all epilepsy syndromes. We investigate educational attainment of children with Self-Limited Epilepsy with CentroTemporal Spikes (SELECTS) in Wales.

Method: A retrospective cohort study using routinely-collected data for children in Wales. We used primary care diagnosis codes to identify children (0–16 years) with SELECTS, other epilepsies, and children without epilepsy (comparators). We linked these records to Key Stage (KS) 2, 3 and 4 (ages 11,14, and 16) national educational test results (2003–2021). We performed logistic regression to analyse attainment (proportion achieving required attainment) in children with SELECTS, other epilepsies, and comparators.

Results: At KS 2,3 and 4: 101,92 and 81 children with SELECTS were matched to 299,274 and 243 children with other epilepsies and comparators. A lower proportion of the SELECTS and other epilepsies groups achieved required attainment than the comparators across all key stages.

After adjusting for sex, deprivation, year of study and Anti-Seizure Medications (ASM), children with SELECTS had similar achievement to comparators in KS2 and KS3:adjusted Odds Ratio (aOR,[95 %CI]) for achieving requirement:KS2:aOR=0.97[0.87–1.09];KS3:aOR=0.99[0.88–1.10]; but slightly reduced KS4 achievement: aOR=0.89,[0.80–1.00]. Children with other epilepsies were significantly less likely to achieve the requirement than comparators:KS2:aOR=0.79[0.72–0.87], KS3:aOR=0.78[0.71–0.86],KS4:aOR=0.72[0.65–0.80].

Conclusions: There was a trend for poorer educational achievement for children with SELECTS at KS4; this was only borderline statistically significant in the adjusted model. Children with other epilepsies had an increased risk of poorer attainment across all ages when compared to children without epilepsy.

1. Introduction

Self-Limited Epilepsy with CentroTemporal Spikes (SELECTS) [previously known as Rolandic Epilepsy or Childhood Epilepsy with Centrotemporal Spikes (CECTS)], is one of the most common, childhood onset, focal epilepsy syndromes accounting for 8–25 % of childhood epilepsies [1–3]. The UK incidence of SELECTS is approximately 5 per 100,000/year [4,5].

SELECTS has historically been labelled as a "benign" form of epilepsy where treatment with Anti-Seizure Medications (ASMs) was not thought to be of benefit [6]. Recent evidence has challenged this view. A significant proportion of children with SELECTS can have cognitive and behavioral problems, and treatment with ASMs could improve outcomes [7,8].

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Children with SELECTS are at higher risk of poorer reading and language comprehension, with SELECTS being associated with poorer outcomes in wider academic settings [8–10]. The main comparator for SELECTS in other studies has often been children with other epilepsies, but more work is needed to investigate the differences between the population as a whole so that the needs of children with SELECTS are not overlooked.

In this study we used linked routinely collected education and healthcare data to compare the educational attainment of children with SELECTS with children with other epilepsies and children without epilepsy.

2. Methods

We performed a retrospective cohort study using routinely collected Welsh healthcare data within the Secure Anonymised Information Linkage (SAIL) databank at Swansea University, Wales, UK [11,12]. SAIL contains anonymised healthcare data from a range of sources. This includes hospital admission and demographic data for the complete Welsh population (3.1 million, 2021 population estimate) and primary care (General Practice [GP]) records for approximately 85 % of the Welsh population. The primary care population covered within SAIL is representative of the Welsh population. An established and validated split-file approach for anonymised data linkage is used within SAIL [11, 12].

We identified children diagnosed with SELECTS aged 0–16 from primary care records using the "F25y4" Read code V2. Read codes are a clinical coding system used to record diagnoses and treatments within primary care in Wales. We used ASM Read codes "dn %" and "do %" (Read codes version 2 beginning with "dn" or "do") to identify all epilepsies. This method has been previously validated to be 83 % sensitive and 93 % specific in childhood epilepsy case ascertainment [13].

We matched each SELECTS case with three children (without replacement) that had any other epilepsy on sex, year of study and **Welsh Index of Multiple Deprivation (WIMD) quintile**. The WIMD uses scores from eight domains, representing different types of deprivation, that are aggregated to form a geographical score for each of 1897 Lower Super Output Areas (LSOAs), each containing an average of 1600 people [14]. Each LSOA in Wales has been ranked from most deprived to least deprived according to its WIMD score and then grouped into quintiles, with quintile 1 being the most deprived and quintile 5 being the least deprived. We additionally matched 3 children without epilepsy from the general population for each SELECTS case on the same matching criteria as a comparator group.

Educational attainment data for each case was extracted from the Department for Children, Education and Lifelong Learning (DCELLS) dataset within the SAIL Databank. The Welsh education system is comprised of four Key Stages: Foundation Phase (0–7 years); Key Stage 2 (7–11 years); Key Stage 3 (11–14 years); and Key Stage 4 (14–16 years).

Children are assessed through a mix of continuous assessment and end of Key Stage exams. Children undertake tests in three core subjects (mathematics, science and English/Welsh) in Key Stage 2, with optional subjects in Key Stages 3 and 4. We used the **Core Subject Indicator (CSI)** to measure the number of children that successfully passed each Key Stage. The CSI is met in Key Stages 2 and 3 if the student achieved the required level or above in all core subjects. In Key Stage 4 the CSI is achieved if the student achieved at least a grade A*–C for all core subjects in their General Certificate of Secondary Education [GCSE] exams. GCSEs are national UK (England, Wales and Northern Ireland) exams taken at the end of Key Stage 4, representing the end of compulsory secondary schooling and a benchmark of academic attainment.

2.1. Statistical analysis

For univariate analysis we compared proportions of children achieving the CSI at each key stage in each group (SELECTS, other epilepsies and comparators). We also recorded the proportion of children prescribed ASMs. P-values were computed from a Pearson's Chi-square test.

For multivariate analysis, we used binary logistic regression, with achievement of the CSI as the outcome variable. We estimated the adjusted odds ratio and 95 % confidence interval for the SELECTS and other epilepsies group versus the comparator group. Each Key Stage was modelled separately. We included the presence of ASM prescription during the Key Stage dates of study as a covariate, as well as the matching variables (sex, year of study [continuous variable] and deprivation) to further minimize any potential confounding bias. We included the year-of-study in particular to allow for potential differences in tests and teaching year-on-year. We don't draw any conclusions from the analysis of the matching variables [19]. All analyses were conducted using R version 4.2.

2.2. Ethical approval

All studies using SAIL data need independent Information Governance Review Panel (IGRP) approval. This study obtained IGRP approval (ref 0895). This study used anonymised, routinely collected, data and therefore written informed consent was not required. The Research Ethics Service has previously confirmed that SAIL projects using anonymised, routinely collected data do not require specific NHS research ethics committee approval.

3. Results

We identified a total of 184 children with SELECTS between 1995 and 2021. Of these 101, 92 and 81 had Key Stage 2, 3 and 4 results available respectively (records available between 2003 and 2021). Each child with SELECTS was matched to three children with epilepsy and three children within the comparator group (Table 1).

Children with SELECTS achieved the Core Subject Indicator [(CSI) – see methods] less frequently than children within the comparator group across all key stages (67.3 % vs 76.6 %, $p = 0.78$; 54.3 % vs 77.7 %, $p < 0.001$; 39.5 % vs 52.3 %, $p = 0.08$). Attainment in the epilepsy cohort was significantly lower than the comparator cohort (39.7 % vs 76.7 %, $p < 0.001$; 34.6 % vs 77.7 %, $p < 0.001$; 30.0 % vs 52.3 %, $p = 0.02$) (Fig. 1 and Table 2). ASMs were less frequently prescribed in the SELECTS group than the other epilepsies group, across all key stages (Table 1).

Table 3 details the results of the multivariate analysis run separately for each key stage. In key stages 2 and 3 the odds ratios for achieving the CSI were not significantly different for the SELECTS versus the comparator group whilst in key stage 4 there was a borderline significant reduction (adjusted OR=0.89 95 %CI=0.80–1.00). Children with other epilepsies had a significantly lower chance of achieving CSI than the comparator group across all key stages.

In each key stage there were no significant differences between the monotherapy and no medication groups. Children with ASM polytherapy were less likely to achieve CSI compared with those not taking ASM in Key Stage 2 with no significant difference in Key Stage 3 (numbers were too small for comparison of the polytherapy group in Key Stage 4).

4. Discussion

To our knowledge this is the one of the largest studies of real-world educational attainment of children with Self-Limited Epilepsy with CentroTemporal Spikes (SELECTS). It spans a large age range (7–16 years), across three national assessment phases (Key Stages), in Wales. We measured outcomes using standardised national educational attainment tests. Each case was matched to three children with other forms of epilepsy and three children without epilepsy in a comparator cohort.

Overall, there was a trend suggesting that children with SELECTS

Table 1
Cohort characteristics. Self-Limited Epilepsy with CentroTemporal Spikes (SELECTS); ASM=anti-seizure medication; WIMD=Welsh Index of Multiple Deprivation (see method); CBZ=Carbamazepine. The columns represent the three cohorts: children with SELECTS; children with other epilepsies and children without epilepsy (comparator group). * not presented due to potential reidentification and disclosure of small numbers.

		No Epilepsy	Epilepsy	SELECTS
Key Stage 2 (7–11 years of age)	**Total**	299 (59 % Male)	299 (59 % Male)	101(59 % Male)
	WIMD Quintile 2014			
	1 (most deprived)	84 (28 %)	84 (28 %)	28 (28 %)
	2	69 (23 %)	69 (23 %)	23 (23 %)
	3	60 (20 %)	60 (20 %)	20 (20 %)
	4	29 (10 %)	29 (10 %)	10 (10 %)
	5 (least deprived)	57 (19 %)	57 (19 %)	20 (20 %)
	ASM			
	No ASM	299 (100 %)	92 (31 %)	50 (50 %)
	Monotherapy - CBZ	0	23 (8 %)	27 (27 %)
	Monotherapy other	0	121 (40 %)	15 (15 %)
	Polytherapy	0	63 (21 %)	9 (9 %)
Key Stage 3 (11–14 years of age)	**Total**	274 (57 % Male)	274 (57 % Male)	92 (58 % Male)
	WIMD Quintile 2014			
	1 (most deprived)	75 (27 %)	75 (27 %)	25 (27 %)
	2	56 (20 %)	56 (20 %)	19 (21 %)
	3	57 (21 %)	57 (21 %)	19 (21 %)
	4	24 (9 %)	24 (9 %)	8 (9 %)
	5 (least deprived)	62 (23 %)	62 (23 %)	21 (23 %)
	ASM			
	No ASM	274 (100 %)	97 (35 %)	56 (61 %)
	Monotherapy - CBZ	0	18 (7 %)	*
	Monotherapy other	0	109 (40 %)	*
	Polytherapy	0	50 (18 %)	*
Key Stage 4 (14–16 years of age)	**Total**	243 (59 % Male)	243 (59 % Male)	81 (56 % Male)
	WIMD Quintile 2014			
	1 Most deprived	57 (23 %)	57 (23 %)	19 (23 %)
	2	51 (21 %)	51 (21 %)	17 (21 %)
	3	48 (20 %)	48 (20 %)	16 (20 %)
	4	27 (11 %)	27 (11 %)	9 (11 %)
	5 Least deprived	60 (25 %)	60 (25 %)	20 (25 %)
	ASM			
	No ASM	243 (100 %)	78 (32 %)	68 (84 %)
	Monotherapy - CBZ	0	13 (5 %)	*
	Monotherapy other	0	113 (47 %)	*
	Polytherapy	0	39 (16 %)	*

were slightly less likely to meet expected national standards in Key Stage 4 when compared to children without epilepsy. This was only borderline significant at Key Stage 4: adjusted odds ratio of achieving the Core Subject Indicator (CSI)=0.89 (95 %CI 0.80–1.00). However, in analyses adjusted for sex, deprivation and year of study the results at Key Stages 2 and 3 were not statistically different.

The findings add to the growing body of evidence that children with SELECTS may be at increased risk of poorer educational performance. 23 % of children in an English cohort of 124 children with SELECTS reported poor school progress [15]. Cognitive difficulties associated with

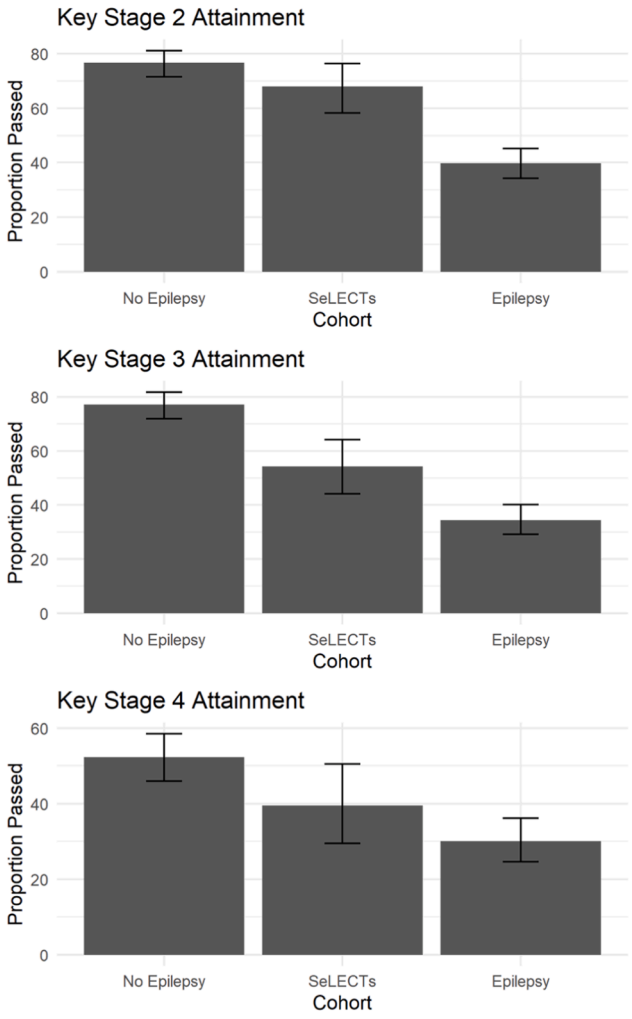

Fig. 1. Educational attainment across Key Stages 2 (age 7–11), Key Stage 3 [11–14] and Key Stage 4 [14–16]. The vertical axis represents the proportion of children in each group achieving the required CSI (Core Subject Indicator) – see method. Error bars on the plot represent 95 % confidence intervals (unadjusted/univariate analysis). The bars represent the three cohorts: children without epilepsy (comparator group); children with Self-Limited Epilepsy with CentroTemporal Spikes (SELECTS); and children with other epilepsies.

Table 2
Educational Attainment results: Key Stage 2,3 and 4 results in terms of proportion of children achieving the core subject indicator (CSI). The SELECTS (Self-Limiting Epilepsy with Centro-Temporal spikes) and epilepsy groups were compared against the comparator cohort (no epilepsy). P-values were computed from a Pearson's Chi-square test, 95 % CI = 95 % confidence interval, using a logit transformed Wald method.

	Cohort	Proportion achieving CSI (%)	95 % CI	p-value
Key Stage 2 (7–11 years of age)	Comparator	230 (76.9 %)	71.5–81.1	(ref)
	All Other Epilepsy	119 (39.8 %)	34.3–45.3	<0.001
	SELECTS	68 (67.3 %)	58.3–76.4	0.78
Key Stage 3 (11–14 years of age)	Comparator	213 (77.7 %)	71.9–81.7	(ref)
	All Other Epilepsy	95 (34.7 %)	29.1–40.2	<0.001
	SELECTS	50 (54.3 %)	44.1–64.2	<0.001
Key Stage 4 (14–16 years of age)	Comparator	127 (52.3 %)	46.0–58.5	(ref)
	All Other Epilepsy	73 (30.0 %)	24.6–36.1	0.02
	SELECTS	32 (39.5 %)	29.5–50.5	0.08

Table 3
Adjusted odds ratios for achieving the Core Subject Indicator (CSI) in each Key Stage using a logistic regression model. Each Key Stage was analysed individually. §Numbers were small in the Key Stage 4 polytherapy group and were not disclosed due to potential reidentification issues.ASM=Anti-seizure medication; WIMD=Welsh Index of Multiple Deprivation.

			Odds ratio	95 % CI	p-value
Key Stage 2 (7–11 years of age)	**Cohort**	Comparator	–	–	(ref)
		Epilepsy	0.79	0.72–0.87	**<0.001**
		SELECTS	0.97	0.87–1.09	0.6
	Sex	Males	–	–	**(ref)**
		Females	1.10	1.02–1.17	**0.009**
	Year of Study		1.02	1.01–1.03	**<0.001**
	WIMD Quintile	1 (Most Deprived)	–	–	(ref)
		2	1.04	0.94–1.14	0.4
		3	1.12	1.02–1.24	**0.02**
		4	1.15	1.01–1.30	**0.03**
		5 (least deprived)	1.17	1.06–1.30	**0.002**
	ASM	Monotherapy	–	–	(ref)
		No medication	1.08	0.97–1.19	0.15
		Polytherapy	0.79	0.70–0.90	**<0.001**
Key Stage 3 (11–14 years of age)	**Cohort**	Comparator	–	–	(ref)
		Epilepsy	0.78	0.71–0.86	**<0.001**
		SELECTS	0.99	0.88–1.10	0.8
	Sex	Males	–	–	(ref)
		Females	1.09	1.02–1.17	**0.013**
	Year of Study		1.02	1.01–1.03	**<0.001**
	WIMD Quintile	1 (Most Deprived)	–	–	(ref)
		2	1.04	0.94–1.14	0.5
		3	1.13	1.02–1.24	**0.016**
		4	1.15	1.01–1.30	**0.032**
		5 (least deprived)	1.17	1.06–1.30	**0.002**
	ASM	Monotherapy	–	–	(ref)
		No medication	1.11	0.95–1.29	0.2
		Polytherapy	1.16	1.00–1.34	0.054
Key Stage 4 (14–16 years of age)	**Cohort**	Comparator	–	–	(ref)
		Epilepsy	0.72	0.65–0.80	**<0.001**
		SELECTS	0.89	0.80–1.00	**0.05**
	Sex*	Males	–	–	**(ref)**
		Females	1.09	1.02–1.17	**0.015**
	Year of Study		1.03	1.01–1.04	**<0.001**
	WIMD Quintile	1 (Most Deprived)	–	–	(ref)
		2	1.11	1.00–1.24	**0.044**
		3	1.12	1.01–1.24	**0.027**
		4	1.33	1.16–1.53	**<0.001**
		5 (least deprived)	1.33	1.20–1.47	**<0.001**
	ASM	Monotherapy	–	–	(ref)
		No medication	1.05	0.95–1.15	0.4
		Polytherapy§	Not calculated	–	–

SELECTS may underlie this trend. A German study of 38 children with SELECTS or Rolandic discharges without seizures, found poorer performance in all cognitive domains when compared to controls [16]. A meta-analysis of literacy and language in children with SELECTS found the presence of reading and phonological processing deficits [17]. Poorer cognitive performance seems to be associated with increased electroencephalogram (EEG) abnormalities [18]. Children with SELECTS also show elevated rates of neuropsychological and behavioural comorbidities, which may also impact educational outcomes [5].

In our study, children with all other types of epilepsy (excluding SELECTS) had an increased risk of poorer performance at all key stages when compared to children without epilepsy and SELECTS. This is consistent with previous data that children with epilepsy are at increased risk of poorer educational achievement [19]. This group of children would have a mix of different types of epilepsies. This would include children with more self-limiting epilepsies as well as children with more severe epilepsies. For example the group of children with epilepsy would have included children with developmental and epileptic encephalopathies, symptomatic structural epilepsies, epilepsies with intellectual disability as well as children with more neurodevelopmental abnormalities [20]. The higher proportion of children on ASM polytherapy in this group, often reflecting increased seizure burden, is also associated with reduced educational achievement [21].

The key strength of this study was the ability to compare a large group of children with SELECTS to well-matched groups of children with other epilepsies and those without epilepsy, while adjusting for key confounders including sex, year of study, and socioeconomic deprivation. We used population-level routinely collected data which reduces the risk of selection bias. Unlike previous studies, which often used language-based assessments outside of school settings and with smaller samples, this study used national-level academic data from standardised assessments [9,10,22,23].

This was a retrospective cohort study. Despite the large sample size compared to other SELECTS studies, the sample size was still relatively small and this limited subgroup analysis. This may be due to the under-recording of SELECTS diagnosis codes in primary care records [5]. Only children with a SELECTS diagnosis code contained within their routinely-collected data could be included in this study and there is a selection bias against the unknown number of SELECTS children without diagnosis codes.

Many factors influence educational attainment. These include seizure frequency which we were unable to account for, given it is not recorded in the routinely collected data in SAIL. We were also unable to consider additional factors including school attendance, parental education level, EEG findings, comorbidities, family structure and adverse social circumstances. We did not record whether the children were educated in independent/fee paying schools. However, in Wales, the vast majority of children (98 %), at the time of the study and currently, are educated in state/public schools [24].

Additionally, the scope of our findings is limited by the educational results not being available for all the SELECTS cohort. This was due to the limited duration of the educational data set (DCELLS). We identified children with SELECTS between 1995 and 2021 but test results were only available between 2003 and 2021.

5. Conclusion

Our study provides some evidence that children with SELECTS may be at an increased risk of subtle, but persistent, educational underachievement when compared to children without epilepsy in national attainment tests. This further underscores the fact that SELECTS is not a “benign” syndrome, and therefore the importance that children with SELECTS are offered appropriate treatment and support. Further research is needed to explore educational attainment in SELECTS including the role of treatment, seizure frequency, and neurodevelopmental comorbidities.

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Authorship contribution statement

ASL performed primary data and statistical analysis. CBJ performed data analysis. RFC conceived, designed and coordinated the study. RFC and WOP provided senior clinical advice and supervision. CJW and JS provided statistical advice and support. All authors were part of the project team reviewing results and progress. ASL and WOP drafted the manuscript. All authors reviewed and edited the manuscript.

Declaration of competing interest

None.

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