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# Effect of childhood coeliac disease on ninth grade school performance: evidence from a population-based study

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## ABSTRACT

**Background** Coeliac disease might affect school performance due to its effect on cognitive performance and related health consequences that might increase school absenteeism. The aim of this study was to investigate whether children with coeliac disease performed differently on completion of ninth grade in school compared with children without coeliac disease.

**Methods** Analysis was performed on a population of 445 669 children born in Sweden between 1991 and 1994 of whom 1767 were diagnosed with coeliac disease. School performance at ninth grade was the outcome and coeliac disease was the exposure. Other covariates included sex, Apgar score at 5 min, small for gestational age, year of birth, family type, parental education and income.

**Results** There was no association between coeliac disease and school performance at ninth grade (adjusted coefficient  $-2.4$ , 95% CI  $5.1$  to  $0.4$ ). A weak association was established between late coeliac diagnosis and higher grades, but this disappeared after adjusting for parent socioeconomic conditions. Being small for gestational age affected performance negatively (adjusted coefficient  $-6.9$ , 95% CI  $8.0$  to  $5.7$ ). Grade scores were significantly lower in children living with a single parent (adjusted coefficient  $-20.6$ , 95% CI  $20.9$  to  $20.2$ ), compared with those with married/cohabiting parents. A positive association was found between scores at ninth grade and parental education and income.

**Conclusion** Coeliac disease diagnosis during childhood is not associated with poor school performance at ninth grade.

## INTRODUCTION

Current evidence suggests a link between health and educational achievements, even though this does not necessarily imply causation.<sup>1 2</sup> Research on childhood health and school performance has shown that low birth weight has a negative impact on children's intellectual capacity<sup>3-5</sup> as well as school achievements.<sup>6 7</sup> Currie and Hyson point out that there are relatively few studies on the effect of health after birth and school performance due to a lack of suitable data.<sup>3</sup> However, the few existing studies suggest such a relationship for several chronic diseases such as diabetes, sickle cell anaemia, seizure disorders, asthma and obesity.<sup>2 8 9</sup>

Coeliac disease is a chronic disorder occurring after birth, but often during childhood.<sup>10</sup> Previously coeliac disease was considered rare, but it is now quite common, with an increasing occurrence

## What is already known on this topic?

- ▶ Childhood chronic diseases are associated with increased risk of low school performance.
- ▶ Adulthood coeliac disease is associated with low cognitive ability.
- ▶ Coeliac disease is associated with several health consequences that may increase school absenteeism.

## What this study adds?

- ▶ Childhood coeliac disease is not associated with school performance at ninth grade.
- ▶ A weak association was found between late coeliac disease diagnosis and high grades, but this disappeared after adjusting for socioeconomic conditions.
- ▶ The study confirms an association between low school performance and living in a single parent household, low parental education and low parental income.

in many populations. On average the prevalence is estimated to be about 1%, but considerably higher in some countries, with up to 3% in some population segments.<sup>11</sup> Coeliac disease has a multifactorial aetiology, with genetics and gluten as necessary factors, but other environmental factors have been implicated.<sup>12-16</sup> We have been unable to find any published studies on coeliac disease and school achievement. However, a few available closely related studies have investigated the effect of coeliac disease on adult intellectual ability and cognitive impairment.<sup>17-21</sup>

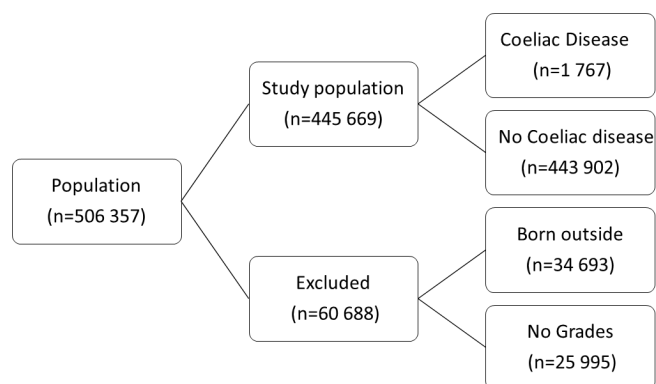
Coeliac disease has systemic effects, it mainly affects the gastrointestinal tract with enteropathy resulting in malabsorption. Today there is only one effective treatment, which is a lifelong strict gluten-free diet, and dietary compliance is challenging. Left untreated, the disease can give a wide range of health consequences such as failure to thrive, nausea/vomiting, diarrhoea or obstipation, anaemia and fatigue.<sup>22-24</sup> Many of these health problems can decrease school attendance and contribute to low school performance.

Several studies have shown coeliac disease to negatively influence the cognitive performance and intellectual ability of adult patients.<sup>17-21</sup> In the USA, lower cognitive ability among the elderly with coeliac disease has been indicated.<sup>17</sup> To our knowledge, no



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**Figure 1** Selection of the study population.

studies to date have looked at coeliac disease in relation to cognitive performance, intellectual ability or school performance in the child population.

Our hypothesis is that childhood coeliac disease negatively affects school performance at ninth grade. Performance at ninth grade is a good measure for overall school performance as these scores are used in determining transition into higher secondary school and as such are important for the entire educational trajectories. Thus, in our study we assessed school performance at ninth grade and how this differs between children with coeliac disease and those without, while adjusting for relevant health, demographic and socioeconomic factors.

## METHODS

### Study population and data availability

The study population consisted of all children born in Sweden between 1991 and 1994. Selection of this birth cohort was based on data availability. It is from 1991 that most cases were reported to the Swedish National Childhood Celiac Disease Register with a personal identity number, a requirement for linkage of registers. Since data were only available up to 2010, majority of these children had only completed ninth grade as the highest level of education.

A total of 506 357 children were identified, of whom 60 688 were excluded either as they were born outside Sweden and therefore lacked health data from birth, or because they lacked data on ninth grade scores (figure 1). A total of 445 669 children were included in the analysis, of whom 1767 had coeliac disease diagnosed, as shown in figure 1.

Data were made available through the Swedish Initiative for Research on Microdata in the Medical and Social Sciences (Umeå SIMSAM Lab) hosting data up to 2010.<sup>25</sup> This is a comprehensive database with selected data from Statistics Sweden, the National Board of Health and Welfare, and the Swedish National Childhood Celiac Disease Incidence Register.<sup>26</sup> Statistics Sweden performed data linkage using personal identity numbers, but before delivery to us the data were anonymised.<sup>27</sup>

Statistics Sweden's Longitudinal Integration Database for Health Insurance and Labour Market (LISA database) provided information on the total population, parents' education and income, and the Swedish National Agency for Education's Pupil Register provided data on school grades. The National Board of Health and Welfare provided data on perinatal events through its Medical Birth Register.

## Outcome

Grade scores on completion of the ninth year of compulsory school education were the outcome of interest. Compulsory school education is from first to ninth grades and each grade is equivalent to 1 year of schooling. A national examination is administered in the ninth year and final grade scores are calculated as the sum of the 16 best subject grades in the final year using grading points. The grading points offer a summary of performance during the final compulsory school year, with grades ranging from 0 to 320 points. For every subject, students are assigned a grade ranging from 0 to 20, where 0 represents failure, 10 is E, 12 is D, 15 is C, 17.5 is B and 20 is A. The lowest obtainable score on all subjects is 0, implying that one has scored 0 in all the tested subjects, while the highest is 320, implying that one has scored 20 in all 16 subjects.

### Independent variable: coeliac disease cases

A total of 1767 children with coeliac disease were identified from all the 47 paediatric units in the country by accessing

**Table 1** The study population with mean scores at ninth grade completion (with SDs) given for each child and parental characteristics, for coeliac disease and non-coeliac disease children

Characteristics	Mean grades (SD)	Coeliac disease (n=1767)	Non-coeliac disease (n=443 902)	Total number
<b>Sex</b>				
Male	198 (62.5)	651	226 963	227 614
Female	220 (64.8)	1116	216 939	218 055
<b>Apgar score at 5 min</b>				
7–10	209 (64.5)	1733	431 895	433 628
<7	206 (64.8)	12	3290	3302
<b>Small for gestational age</b>				
No	209 (64.6)	1659	431 895	418 598
Yes	198 (67.1)	38	3290	10 096
<b>Age at diagnosis (years)</b>				
0–5	208 (63.3)	671	0	671
6–12	211 (66.5)	806	0	806
13–15	220 (62.1)	290	0	290
<b>Year of birth</b>				
1991	207 (64.6)	402	115 529	115 931
1992	209 (64.7)	451	114 225	114 676
1993	209 (64.8)	598	109 377	109 975
1994	210 (64.3)	316	104 771	105 087
<b>Type of family</b>				
Married/cohabiting	216 (60.1)	1268	312 771	314 039
Single	190 (70.7)	498	130 856	131 354
<b>Parental education</b>				
Compulsory	163 (71.5)	35	15 225	15 260
Upper secondary	191 (63.1)	848	209 505	210 353
<2 years university	219 (58.9)	143	33 735	33 878
≥2 years university	231 (58.5)	741	185 437	186 178
<b>Mother's income</b>				
Low	198 (66.4)	503	136 877	137 380
Middle	206 (62.2)	607	149 267	149 874
High	223 (62.1)	634	150 327	150 961
<b>Father's income</b>				
Low	192 (68.6)	429	131 453	131 882
Middle	206 (60.1)	653	146 966	147 619
High	229 (57.9)	622	149 310	149 932

**Table 2** Impact of coeliac disease on school achievement at ninth grade completion, taking child and parental characteristics into account

Child and parental characteristics		Model 1		Model 2		Model 3		Model 4	
		b	95% CI	b	95% CI	b	95% CI	b	95% CI
Coeliac disease status	No	Ref		Ref		Ref		Ref	
	Yes	2.8	−0.2 to 5.8	−0.5	−3.5 to 2.5	−0.6	−3.7 to 2.4	−2.4	−5.1 to 0.4
Sex	Male			Ref		Ref		Ref	
	Female			22.4**	21.9 to 22.7	22.5**	22.1 to 22.9	22.5**	22.2 to 22.9
Year of birth	1991			Ref		Ref		Ref	
	1992			2.1**	1.5 to 2.6	1.9**	1.5 to 2.5	−0.6*	−1.1 to −0.1
	1993			2.9**	2.5 to 3.5	2.9**	2.4 to 3.5	−1.4**	−1.9 to −0.9
	1994			3.1**	2.6 to 3.6	2.9**	2.4 to 3.5	−2.5**	−2.9 to −1.9
Apgar score at 5 min	7–10					Ref		Ref	
	<7					−1.8	−4.1 to 0.5	−1.0	−3.1 to 1.1
Small for gestational age	No					Ref		Ref	
	Yes					−10.8**	−12.0 to −9.5	−6.9**	−8.0 to −5.7
Family type	Married/cohabiting							Ref	
	Single							−20.6**	−20.9 to −20.2
Parental education	≤9 years schooling							Ref	
	Upper secondary							21.5**	20.5 to 22.5
	University <2 years							42.5**	41.3 to 43.6
	University ≥2 years							52.5**	51.5 to 53.5
Mother's income	Low							Ref	
	Middle							5.5**	5.0 to 5.9
	High							15.4**	14.9 to 15.8
Father's income	Low							Ref	
	Middle							9.3**	8.8 to 9.7
	High							22.1**	21.6 to 22.5

Model 1 contains only coeliac disease status, model 2 contains coeliac disease status plus children's demographic characteristics, model 3 contains model 2 plus children's health characteristics, and model 4 contains model 3 plus parental characteristic.

Ordinary least squares regression, b=unstandardised coefficients, n=445 669.

\*p<0.05; \*\*p<0.001.

the Swedish National Childhood Celiac Disease Incidence Register.<sup>26</sup> Ascertainment of coeliac disease status was based on the 1990 diagnostic criteria by ESPGHAN (the European Society for Paediatric Gastroenterology, Hepatology and Nutrition). This implies that coeliac disease is ascertained by a biopsy assessment of the small intestinal mucosa showing an enteropathy on a gluten-containing diet, followed by a clinical improvement after a change to a gluten-free diet. Child age at the coeliac disease diagnosis was given for the age intervals 0–5 years, 6–12 years and 13–15 years (15.9 years); in a subanalysis the youngest group was compared with the older groups.

### Covariates: other characteristics

Variables were selected if they had been previously suggested to be associated with both health and school achievements. For child characteristics we included the following: sex, small for gestational age, Apgar score at 5 min (a measure of the newborn's physical condition 5 min after birth) and year of birth. Sex was grouped into female and male, and there were no missing data. Apgar score at 5 min was categorised according to established criteria into low if the score was <7 and normal if the score was within the range of 7–10. Data were missing for 7%. Small for gestational age was precategorised into two groups (yes and no) according to the Swedish weight-based growth standards. Children are classified as small for gestational age if birth weight is 2 SD below the mean at a certain pregnancy length and not small for gestational age if otherwise. Data were missing for 9%. Year of birth ranged from 1991 to 1994, and this information was available for all children.

We included parental characteristics that previous studies have considered to be strongly associated with school performance and educational attainment.<sup>28–30</sup> Initially, we planned to include maternal and paternal educational levels as two separate variables, but due to a strong correlation categorisation was based on the highest education of the mother or the father. This variable was divided into four groups: compulsory education (reference), upper secondary education, <2 years of university education and ≥2 years of university education. Maternal and paternal disposable income at the child's completion of ninth grade (per 100 SEK) was categorised into tertiles. The groups were labelled low (reference), middle and high (information was missing for fathers' income for 4% and mother's income for 2%). Type of family was categorised into two groups: married/cohabiting and single for all those living alone, that is, widows, widowers, divorced, separated and never married.

### Statistical analysis

The multiple linear regression procedure was used to assess how well coeliac disease predicted ninth grade scores. Other studied covariates were added step-by-step to assess any confounding, and this was done by running four models separately. Model 1 consisted of a coeliac disease status alone. In model 2, the child's demographic factors were added (sex, year of birth). In model 3, child's health factors (Apgar score and small for gestational age) were added. In model 4, family type, parental education, and mother and father's income were added. In a separate analysis that only included coeliac disease cases, we checked whether age at diagnosis of coeliac disease affected the performance at ninth

**Table 3** Impact of age at diagnosis of coeliac disease on school achievement at ninth grade completion, taking child and parental characteristics into account

Child and parental characteristics		Model 1C		Model 2C		Model 3C		Model 4C	
		b	95% CI	b	95% CI	b	95% CI	b	95% CI
Age at diagnosis (years)	0–12	Ref		Ref		Ref		Ref	
	13–15	9.9*	1.8 to 18.1	10.5*	2.3 to 18.6	11.6*	3.3 to 19.9	7.1	−0.2 to 14.8
Sex	Male			Ref		Ref		Ref	
	Female			22.1**	15.9 to 28.3	21.3**	14.9 to 27.6	22.9**	17.5 to 28.6
Year of birth	1991			Ref		Ref		Ref	
	1992			−4.6	−13.2 to 3.9	−3.9	−12.7 to 4.9	−7.3	−13.8 to 2.0
	1993			5.5	−2.6 to 13.6	5.8	−2.5 to 14.1	0.1	−6.2 to 8.7
	1994			3.1	−6.3 to 12.5	2.8	−6.8 to 12.0	−1.3	−9.4 to 7.2
Apgar score at 5 min	7–10					Ref		Ref	
	<7					11.2	−26.8 to 49.2	15.1	−20.8 to 45.5
Small for gestational age	No					Ref		Ref	
	Yes					−14.8	−35.7 to 6.1	−9.4	−26.7 to 8.9
Family type	Married/cohabiting							Ref	
	Single							−22.4**	−28.0 to −15.7
Mothers' education	≤9 years schooling							Ref	
	Upper secondary							23.1**	10.0 to 31.7
	University <2 years							46.2**	27.8 to 61.2
	University ≥2 years							45.3**	31.6 to 54.7
Mother's income	Low							Ref	
	Middle							6.4	1.2 to 14.8
	High							12.8*	6.2 to 20.2
Father's education	≤9 years schooling							Ref	
	Upper secondary							15.1**	7.2 to 22.9
	University <2 years							31.9**	19.4 to 43.4
	University >2 years							32.0**	21.6 to 41.0
Father's income	Low							Ref	
	Middle							8.6**	2.3 to 16.0
	High							17.7**	11.1 to 25.8

Model 1C contains age at diagnosis, model 2C contains age at diagnosis plus children's demographic characteristics, model 3C contains model 2 plus children's health characteristics, and model 4C contains model 3 plus parental characteristics.

Ordinary least squares regression, b=unstandardised coefficients, n=1767.

\*p<0.05; \*\*p<0.001.

grade. In this analysis, the first model (model 1C) only included age at diagnosis of the disease; however, thereafter the models were built stepwise (models 2C–4C) as in the previous analyses. A statistically significant association was defined as having 95% CIs that did not include 0, corresponding to  $p<0.05$ . Statistics were calculated using SPSS V.24.0 2000.

### Ethical consideration

This study was approved by the Research Ethics Committee of the Umeå University. Subject information was anonymised by Statistics Sweden prior to the analyses.

### RESULT

During this follow-up period, the mean age for completion of ninth grade was 16 years and the mean grade score for this population was 207 (SD=66). Additional basic descriptive statistics are shown in [table 1](#).

### Child characteristics and school performance

We found no significant association between coeliac disease and school performance at ninth grade ([table 2](#)). In these birth cohorts (1991–1994), girls performed better than boys at ninth grade. Using the 1991 birth cohort as a reference, a noticeable annual drop in grades was seen for later cohorts. Apgar score showed

no significant association with school grades while being born small for gestational age appeared to negatively impact children's performance. Notably, children with coeliac disease diagnosed at 13–15 years of age performed better in ninth grade compared with children diagnosed earlier in life; however, this relationship disappeared after adjusting for parental characteristics ([table 3](#)).

### Parental characteristics and school performance

Living in a household with an unmarried/non-cohabiting parent was significantly associated with poorer performance at ninth grade compared with living in a household of married/cohabiting parents. Scores at ninth grade were also significantly associated with parental education and income; the higher the levels of parental education and income, the higher the grade scores on completion of the ninth grade. For all interaction terms included, we found no statistically significant association and thus these results are not shown.

### DISCUSSION

From existing research, we know that health is important for academic performance and eventual educational attainment. What we did not know was whether coeliac disease influences school performance. Based on findings from this study, coeliac disease is not significantly associated with grade scores on



completion of the ninth grade. However, being small for gestational age, being born after 1991 and living in a single parent household were all strongly associated with low performance. In contrast, high performance at ninth grade was predicted by being female and having parents with high education and income.

### Coeliac disease and school performance

The absence of an association between coeliac disease and school performance is probably due to early coeliac disease diagnosis and adherence to a gluten-free diet. This study hypothesised that coeliac disease may affect school performance based on evidence from earlier studies showing a link between coeliac disease and cognitive performance. However, these earlier studies were performed on adult populations, whereas cases in the present study were diagnosed between 0 and 15 years of age. It may be that the negative effect of coeliac disease is only evident following long exposure to gluten such as in individuals with a delayed diagnosis. Hu *et al* showed the impact of coeliac disease on cognitive performance to be more pronounced in the elderly.<sup>17</sup> Similarly, Hadjivassiliou *et al* reported that the onset of symptoms of cognitive dysfunction occurred on average at 53 years of age among patients with gluten ataxia.<sup>21</sup> Casella *et al* confirmed that poor cognitive performance was pronounced in patients diagnosed with coeliac disease during adulthood.<sup>18</sup> Additionally, it is plausible that our cases adhere to the recommended strict gluten-free diet and thus are living a relatively normal life following early diagnosis. Even though we did not include data on nutrition, the earlier study from this population reported an 82% gluten-free diet compliance rate.<sup>31</sup> Interestingly, age at diagnosis did not appear to play a significant role. Children diagnosed after 13 years of age tended to perform better. However, this could be due to a socioeconomic bias, as this relationship disappeared when we controlled for resources, that is, parental education and income.

### Other child characteristics and school performance

The finding that children born small for gestational age performed poorly at ninth grade compared with others is in line with previous studies.<sup>32</sup> The mechanism underlying pregnancy length at birth and performance at ninth grade is likely to be multifactorial; it has been suggested that preterm children have an increased risk of delayed development, cognitive impairments, learning disabilities, behavioural problems and emotional problems, among other issues.<sup>33</sup> These factors negatively impact school performance. Our findings on decreasing school performance in birth cohorts over time and better performance among girls are also in line with earlier studies.<sup>34</sup> This study does not explain why there is decrease in performance at ninth grade in the recent years or as to why girls outperform boys, further research is needed.

### Parental conditions and school performance

We reported that school performance at ninth grade was positively associated with parental income and education. This finding confirms a well-documented association between socioeconomic status and academic achievement.<sup>35</sup> Parental income reflects the economic and social resources available to the child, and parental education was linked to both parental income and levels of engagement in the child's education.<sup>36</sup> Low performance was significantly higher in children living with non-married/non-cohabiting parents, and similar observations have been shown by earlier studies.<sup>37</sup> This negative effect has previously been attributed to detrimental stress arising from parental conflict following divorce/separation, the meagre economic

resources typical in most one-parent homes and time pressures on single parents making them less able to participate in the child's schooling.<sup>37 38</sup>

### CONCLUSION

In conclusion, coeliac disease diagnosed during childhood in Sweden is not associated with poor school performance at ninth grade.

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**Contributors** MS and KN were responsible for the conceptualisation of the study, supervised the analysis process and offered quality control of both data and the final study results. AI provided clinical insights and interpretation of the study variables and the research findings. FN performed the statistical analyses and wrote the manuscript. All authors contributed to the selection of the studied variables, choice of study design, interpretation of study findings, and revision of the manuscript, and have approved the submitted version of the manuscript.

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**Competing interests** None declared.

**Ethics approval** Swedish Ethical Review Board.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data sharing statement** All data for this study are available through the Umeå SIMSAM Lab. More data similar to the one used in this study can be obtained from Statistics Sweden and the Swedish National Board of Health and Welfare upon request and ethical clearance.

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