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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.

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.

INTRODUCTION

Current evidence suggests a link between health and educational achievements, even though this does not necessarily imply causation.[1 2] Research on childhood health and school performance has shown that low birth weight has a negative impact on children's intellectual capacity[3–5] as well as school achievements.[6 7] 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.[3] However, the few existing studies suggest such a relationship for several chronic diseases such as diabetes, sickle cell anaemia, seizure disorders, asthma and obesity.[2 8 9]

Coeliac disease is a chronic disorder occurring after birth, but often during childhood.[10] Previously coeliac disease was considered rare, but it is now quite common, with an increasing occurrence 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.[11] Coeliac disease has a multifactorial aetiology, with genetics and gluten as necessary factors, but other environmental factors have been implicated.[12–16] 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.[17–21]

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.[22–24] 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.[17–21] In the USA, lower cognitive ability among the elderly with coeliac disease has been indicated.[17] To our knowledge, no

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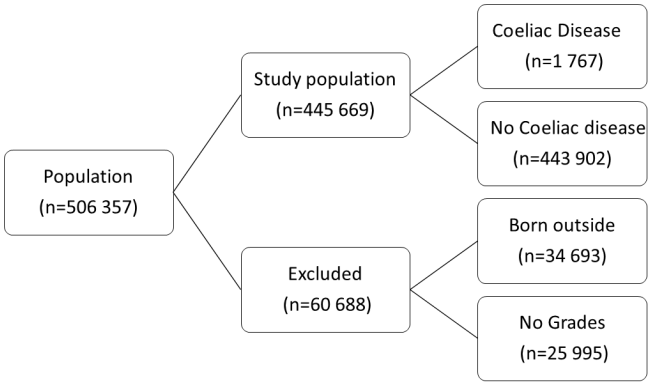

Figure 1 Selection of the study population.

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.[25] 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.[26] Statistics Sweden performed data linkage using personal identity numbers, but before delivery to us the data were anonymised.[27]

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
Sex				
Male	198 (62.5)	651	226 963	227 614
Female	220 (64.8)	1116	216 939	218 055
Apgar score at 5 min				
7–10	209 (64.5)	1733	431 895	433 628
<7	206 (64.8)	12	3290	3302
Small for gestational age				
No	209 (64.6)	1659	431 895	418 598
Yes	198 (67.1)	38	3290	10 096
Age at diagnosis (years)				
0–5	208 (63.3)	671	0	671
6–12	211 (66.5)	806	0	806
13–15	220 (62.1)	290	0	290
Year of birth				
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
Type of family				
Married/cohabiting	216 (60.1)	1268	312 771	314 039
Single	190 (70.7)	498	130 856	131 354
Parental education				
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
Mother's income				
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
Father's income				
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

		Model 1		Model 2		Model 3		Model 4	
Child and parental characteristics		**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.[26] 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.[28–30] 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

		Model 1C		Model 2C		Model 3C		Model 4C	
Child and parental characteristics		**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 celiac 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.[17] 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.[21] Casella *et al* confirmed that poor cognitive performance was pronounced in patients diagnosed with coeliac disease during adulthood.[18] 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.[31] 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.[32] 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.[33] 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.[34] 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.[35] 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.[36] Low performance was significantly higher in children living with non-married/non-cohabiting parents, and similar observations have been shown by earlier studies.[37] 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.[37 38]

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.

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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.

REFERENCES

1 Brown JO, Grubb SB, Wicker TE, *et al*. Health variables and school achievement. *J Sch Health* 1985;55:21–3.
2 Forrest CB, Bevans KB, Riley AW, *et al*. Health and school outcomes during children's transition into adolescence. *J Adolesc Health* 2013;52:186–94.
3 Currie J, Hyson R. Is the impact of Health Shocks cushioned by socioeconomic status? the case of low birthweight. *Am Econ Rev* 1999;89:245–50.
4 Bergvall N, Iliadou A, Tuvemo T, *et al*. Birth characteristics and risk of low intellectual performance in early adulthood: are the associations confounded by socioeconomic factors in adolescence or familial effects? *Pediatrics* 2006;117:714–21.
5 Torche F, Echevarría G. The effect of birthweight on childhood cognitive development in a middle-income country. *Int J Epidemiol* 2011;40:1008–18.
6 Ross G, Lipper EG, Auld PA, *et al*. Educational status and school-related abilities of very low birth weight premature children. *Pediatrics* 1991;88:1125–34.
7 Saigal S, Szatmari P, Rosenbaum P, *et al*. Cognitive abilities and school performance of extremely low birth weight children and matched term control children at age 8 years: a regional study. *J Pediatr* 1991;118:751–60.
8 Taras H, Potts-Datema W. Chronic health conditions and student performance at school. *J Sch Health* 2005;75:255–66.
9 Crump C, Rivera D, London R, *et al*. Chronic health conditions and school performance among children and youth. *Ann Epidemiol* 2013;23:179–84.
10 Green PH, Jabri B. Coeliac disease. *Lancet* 2003;362:383–91.
11 Myléus A, Ivarsson A, Webb C, *et al*. Celiac disease revealed in 3% of swedish 12-year-olds born during an epidemic. *J Pediatr Gastroenterol Nutr* 2009;49:170–6.
12 Namatovu F, Olsson C, Lindkvist M, *et al*. Maternal and perinatal conditions and the risk of developing celiac disease during childhood. *BMC Pediatr* 2016;16:1–10.
13 Namatovu F, Sandström O, Olsson C, *et al*. Celiac disease risk varies between birth cohorts, generating hypotheses about causality: evidence from 36 years of population-based follow-up. *BMC Gastroenterol* 2014;14:59.
14 Namatovu F, Strömgren M, Ivarsson A, *et al*. Neighborhood conditions and celiac disease risk among children in Sweden. *Scand J Public Health* 2014;42:572–80.
15 Namatovu F, Lindkvist M, Olsson C, *et al*. Season and region of birth as risk factors for coeliac disease a key to the aetiology? *Arch Dis Child* 2016;101:1114–8.

16 Roberts SE, Williams JG, Meddings D, *et al*. Perinatal risk factors and coeliac disease in children and young adults: a record linkage study. *Aliment Pharmacol Ther* 2009;29:222–31.
17 Hu WT, Murray JA, Greenaway MC, *et al*. Cognitive impairment and celiac disease. *Arch Neurol* 2006;63:1440–6.
18 Casella S, Zanini B, Lanzarotto F, *et al*. Cognitive performance is impaired in coeliac patients on gluten free diet: a case-control study in patients older than 65 years of age. *Dig Liver Dis* 2012;44:729–35.
19 Lichtwark IT, Newnham ED, Robinson SR, *et al*. Cognitive impairment in coeliac disease improves on a gluten-free diet and correlates with histological and serological indices of disease severity. *Aliment Pharmacol Ther* 2014;40:160–70.
20 Hallert C, Aström J. Intellectual ability of adults after lifelong intestinal malabsorption due to coeliac disease. *J Neurol Neurosurg Psychiatry* 1983;46:87–9.
21 Hadjivassiliou M, Sanders DS, Grünewald RA, *et al*. Gluten sensitivity: from gut to brain. *Lancet Neurol* 2010;9:318–30.
22 Kurppa K, Collin P, Sievänen H, *et al*. Gastrointestinal symptoms, quality of life and bone mineral density in mild enteropathic coeliac disease: a prospective clinical trial. *Scand J Gastroenterol* 2010;45:305–14.
23 Kurien M, Barratt SM, Sanders DS. Functional gastrointestinal disorders and coeliac disease in adults - negative impact on quality of life. *Aliment Pharmacol Ther* 2011;34:1044–5.
24 Mukherjee R, Kelly CP, Leffler DA. Gastrointestinal Cancer in celiac disease: "the first days are the hardest days, don't you worry anymore?". *Clin Gastroenterol Hepatol* 2012;10:4–6.
25 Lindgren U, Nilsson K, de Luna X, *et al*. Data Resource Profile: Swedish Microdata Research from Childhood into Lifelong Health and Welfare (Umeå SIMSAM Lab). *Int J Epidemiol* 2016;45:dyv358.
26 Ivarsson A, Persson LA, Nyström L, *et al*. Epidemic of coeliac disease in Swedish children. *Acta Paediatr* 2000;89:165–71.
27 Ludvigsson JF, Otterblad-Olausson P, Pettersson BU, *et al*. The swedish personal identity number: possibilities and pitfalls in healthcare and medical research. *Eur J Epidemiol* 2009;24:659–67.
28 Evans GW, Schamberg MA. Childhood poverty, chronic stress, and adult working memory. *Proc Natl Acad Sci U S A* 2009;106:6545–9.
29 Murnane RJ. Improving the education of children living in poverty. *Future Child* 2007;17:161–82.
30 Chen E, Martin AD, Matthews KA. Trajectories of socioeconomic status across children's lifetime predict health. *Pediatrics* 2007;120:e297–e303.
31 Webb C, Myléus A, Norström F, *et al*. High adherence to a gluten-free diet in adolescents with screening-detected celiac disease. *J Pediatr Gastroenterol Nutr* 2015;60:54–9.
32 Noble KG, Fifer WP, Rauh VA, *et al*. Academic achievement varies with gestational age among children born at term. *Pediatrics* 2012;130:e257–e264.
33 Stjernqvist K, Svenningsen NW. Ten-year follow-up of children born before 29 gestational weeks: health, cognitive development, behaviour and school achievement. *Acta Paediatr* 1999;88:557–62.
34 Blanchenay P, Burns T, Köster F. Shifting Responsibilities-20 Years of Education Devolution in Sweden. Sweden: OECD Publishing.
35 Sirin SR, Status S. Socioeconomic status and Academic Achievement: a Meta-Analytic Review of Research. *Rev Educ Res* 2005;75:417–53.
36 Szumski G, Karwowski M. School achievement of children with intellectual disability: the role of socioeconomic status, placement, and parents' engagement. *Res Dev Disabil* 2012;33:1615–25.
37 Amato PR. Children of divorce in the 1990s: an update of the Amato and Keith (1991) meta-analysis. *J Fam Psychol* 2001;15:355–70.
38 Sl P, Dronkers J, Hampden-Thompson G, *et al*. Family Policies and Children's School Achievement in Single- Versus Two-Parent Families. *Journal of Marriage and Family* 2003;65:681–99.

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