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Health problems during childhood and school achievement: Exploring associations between hospitalization exposures, gender, timing, and compulsory school grades

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Data Availability Statement: Our data analysis is based on a record linked register database available at the Umeå SIMSAM Labarotory at Umeå University, Sweden. The database is built as a combination of different population based registers linked through Swedish personal numbers, and was compiled in collaboration with different Swedish authorities. Both the approval from the Ethical vetting board and the contracts we have signed with the Swedish authorities do not allow us to give away the data to a third party. The data can

Abstract

Aims

To investigate while accounting for health at birth 1) associations between health problems during childhood, measured as hospitalizations, and school achievement in the final year of compulsory school, measured as overall grade points and eligibility for upper secondary education, 2) if and how gender moderates the association between health problems and school achievement, 3) if and how the timing of a health problem during childhood is associated with later school achievement.

Methods

Analyzes were performed on a population-based cohort (n = 115 196) born in 1990 in Sweden (51.3% boys, 48.7% girls) using data from several national registries. Multiple linear regression and logistic regression were used to analyze associations between study variables.

Results

Overall grade points and eligibility for continuation to upper secondary school were lower for individuals exposed to hospitalizations. Only the association between hospitalizations and overall grade points was moderated by gender and only for ages 13–16 years. Exposure close to actual grading had worst outcomes.

Conclusions

Health problems, measured through hospitalizations, was significantly associated with lower school achievements among Swedish children. Girls exposed to health problems requiring hospitalizations had relatively poorer school achievements as compared to boys. Health problems requiring hospitalization during junior high school had the greatest negative association with final achievement at compulsory school.

however been accessed by any researchers wanting to replicate the analysis, although this can be done only locally at the Umeå SIMSAM Laboratory where the data is stored on servers disconnected from the internet. Contact information: http://www.org.umu.se/simsam/english/about-us/contact-information/ Specific contact for arranging data access: jenny.haggstrom@umu.se.

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Introduction

Many factors across multiple domains influence whether children and adolescents succeed in their educational attainment [1–2], and health is an important prerequisite for successful schooling [3–11]. Previous research on childhood health and later educational outcomes has largely been both condition specific and country specific. The World Health Organization has stated that the overwhelming majority of research is from the United States and has called for further European evidence [12]. As health and educational systems differ between countries, findings from one country might not be directly transferrable to others. In Sweden, research into how health affects education is categorized as a field "under development" [13], meaning that gaps in research still remain. Apart from one previous study [14], Swedish register data has been underutilized in investigating the relationship between health during childhood and school achievements and, furthermore, the study did not take into account birth health status, which has proven to be a significant predictor of childhood health and future life outcomes [4,5]. In the present study, we further utilized the potential of Swedish register data, including several indicators of pre-natal and birth health status, to investigate how health problems during childhood, measured as hospitalizations, are associated with school achievement in the form of overall grade points and eligibility for upper secondary education in the final year of compulsory school.

One central issue in research in education and schoolchildren's health has long been gender differences. It has long been recognized that girls as a group perform better than boys in school [15], and also that girls in most of the industrialized countries have poorer self-reported health [16], which also is the case in Sweden [17]; girls in the early teens are more likely to report poor health and multiple health complaints compared with boys [18–20]. Although these differences are of great public health interest, they have only been studied separately; some have studied gender differences in school achievement on one hand [21,22] others gender differences in health on the other [23,24]. Consequently, there is currently a lack of systematic comparison and unlike previous investigations, the present study formally tested differences and examined whether girls and boys with health problems requiring hospitalization are affected differently in their school achievement.

Another important aspect we for reasons related to lack of sufficient data [7] have limited knowledge of, is if and how the timing of a health problem during childhood impacts later school achievement. Studies based on longitudinal data from the British National Child Development Study [25–28], albeit with a wider scope in studying childhood health and later life outcomes, have revealed a cumulative effect of so-called "systems" conditions (which include heart, lungs, digestive, blood, urogenital and neurological conditions) on educational outcomes, suggesting that the timing of when a health condition occurs is important. However, this was not studied further. Needless to say, these studies were limited regarding national and temporal contexts as they only focused on Great Britain and its educational system during the 1970's. In a Swedish context, a register based study found that later hospitalizations had a greater impact on grades [15] while research into one specific health condition, i.e., diabetes, found that the condition is not only associated with lower school achievements [29–31] but the age of onset seems to play a role [32] and there is a cumulative effect of the disease as well: children with earlier onset diabetes suffer a greater disadvantage in their schooling, reflected as lower school grades, as a result of the disease [33]. Apart from these studies, the question of timing has received little attention.

Study aims

The present study aimed to investigate the association between health problems requiring hospitalization during childhood and school achievements in compulsory school in the form of 1)

overall grade points, and 2) eligibility for continuation to upper secondary education. Overall grade points indicate differences in levels of school achievement while eligibility for continuation to upper secondary education indicate problems of completing education at all. The study expands current knowledge in three ways. First, using hospitalizations as a measure of health problems is advantageous as it includes many different health conditions, it thus serves as a summarizing measure of health problems in the study-population, in contrast to previous mostly condition-specific research, while at the same time indicating serious health problems. Second, we specifically investigated if and how gender moderates the association between hospitalizations on school achievement measured as overall grade points and eligibility for upper secondary education. Third, we investigated the timing of hospitalization exposure; the differences between exposure to hospitalizations early in life before entrance into the Swedish school system vs. exposure to hospitalizations in later years after school entry, and its association with school achievements.

Materials and methods

Data were provided by the Umeå SIMSAM Lab infrastructure [34], which was designed to address questions on childhood, health and welfare. It covers the entire Swedish population between 1960 and 2010, and includes micro-level information from a large number of registers. Individuals are linked between registers with a unique, anonymized, personal identification number. We used data from the Medical Birth Register (MBR) to obtain information on birth health status (for content, quality and previous use of the MBR see Källén and Källén [35], Axelsson [36] and Odlind et al. [37].). Information on hospitalizations and length of stay at medical care events was obtained from the Swedish National Patient Register (NPR). The NPR has been validated in previous studies [38,39]. Information on grades was obtained from the Swedish National Agency of Education's Pupil Register. Data on parental education level and family type were obtained from Statistics Sweden. The present study total population comprised every person born in 1990 who was alive and residing in Sweden in 2010 (n = 135 027). Three exclusions were made, i.e., all foreign-born individuals, all persons born in Sweden with missing data on Apgar score 5 minutes after birth (because we wanted to include data on birth health status) and the few individuals with adoptive mothers and/or fathers. After these exclusions, our analytical sample consisted of n = 115 196 individuals (59 140 boys (51.3%) and 56 056 girls (48.7%)). The Regional Ethical Vetting Board in Umeå approved all research based on data from the Umeå SIMSAM Lab, including the present study.

School achievement

School achievement was measured using two variables: *overall grade points* and *eligibility for upper secondary education*. Overall grade points is the sum of the 16 best subject grades in 9th and final grade of compulsory school; it is received at age 15–16. The grading points indicate differences in levels of school achievement and are a summary of performance, with grades ranging from 0 to 320 points. For every subject, students are assigned a grade ranging from 0 to 20, where 0 is failure. The lowest 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. Overall grade points is a continuous variable and fairly normally distributed In our study sample, 3238 individuals had missing grade points. These individuals had failed to complete compulsory school on time. We coded their overall grade points as "0".

Eligibility for upper secondary education was assessed at the time the cohort was in the ninth grade based on having completed compulsory school with pass grades in the core subjects Swedish, English, and mathematics, which was a requirement for studies in national

upper secondary level education programs. A dummy variable (0/1) was created for passing grades in all three core subjects (0) or failure in one or more of the three core subjects (1), thus assessing ineligibility for upper secondary education.

Health problems

As a measure of health problems, we used *hospitalizations*. Information on hospitalizations was retrieved from the NPR and contains data on all in-patient medical care events in Swedish hospitals. If an individual had experienced a medical care event in a particular year, we defined that individual as exposed to health problems that year. Based on the total length of stay an individual could have a score of "0" in the registry, which indicated a visit to a hospital but without an overnight stay. We defined a score greater than "0" as a serious health problem because it required overnight hospitalization and less than "1" as no hospitalization. We used the number of nights hospitalized in our analyzes. Furthermore, since we were interested in the timing aspect of exposure to health problems, time of exposure was defined by having been hospitalized only during the years prior to formal schooling (age 0–6 years), only during the years after school entry through middle school (age 7–12 years), or only during the years in junior high school (age 13–16 years). These age range groupings were chosen due to the institutional schooling structure in Sweden.

Covariates

Gender was dummy coded as male = 0, female = 1. *Apgar score at 5 minutes* is a measure of a new-born's physical condition after birth (low/normal): an Apgar score lower than 7 is considered low and within 7–10 is normal [40]. Owing to the exclusions, there were no missing data for Apgar score. Data on *low or high birthweight* at gestational age [41] were also included (yes/no). Data were missing for 2.5% of the cohort. *Maternal smoking habits* upon admission to maternity care (no smoking, 1–9 cigarettes/day, $\geq$10 cigarettes/day) can be used as an indicator of in-utero environment, but as tobacco use follows a social gradient, this should primarily be seen as a reflection of social position [42–44]. No data were missing *on maternal smoking habits*. We also included other sociodemographic variables associated with school achievement such as parental level of education and family type [45–47]. *Father's highest education* and *mother's highest education* was observed the year the child received the final grades of compulsory school (compulsory education/two years of upper secondary education/three years of upper secondary education/university education, two years or more including postgraduate education). Data were missing for 3% of the cohort. *Family type* was categorized as married/cohabiting biological parents when the child was 16 years of age (yes/no). Data were missing for 0.3%. Our cohort consisted of only individuals born in Sweden. However, to control for the potential influence of different cultural and immigrant backgrounds, we included *maternal country of birth* (Sweden, Nordic countries, European countries or countries outside Europe). No data were missing for this variable. Finally, we considered a total *municipal average grade point* variable based on data from the Swedish National Agency for Education. This variable was used to adjust for difference in school quality throughout the country. Data were missing for 3%. The study variables are shown in Table 1.

Statistical analyses

We used multiple linear regression to analyze how hospitalizations were associated to overall grade points in the ninth grade of compulsory school. Overall grade points is a continuous and normally distributed variable. The association between hospitalizations and eligibility for upper secondary education was analyzed using logistic regression. Two separate analyzes were

Table 1. The study population and background variables stratified by hospitalization exposures.

	Hospitalization, n (%)						Total, n (%)
	Never	1 night	2–5 nights	6–10 nights	11–50 nights	≥ 51 nights	
All individuals	58 725 (51.0)	15 744 (13.7)	23 878 (20.7)	7538 (6.5)	7980 (6.9)	1331 (1.2)	115 196
Boys	28 228 (24.5)	8394 (7.3)	13 110 (11.4)	4252 (3.7)	4488 (3.9)	668 (0.6)	59 140 (51.3)
Girls	30 497 (26.5)	7350 (6.4)	10 768 (9.3)	3286 (2.9)	3492 (3.0)	663 (0.6)	56 056 (48.7)
Maternal country of birth							
Sweden	51 625 (44.8)	14 011 (12.2)	21 053 (18.3)	6593 (5.7)	7027 (6.1)	1170 (1.0)	101 479 (88.1)
Nordic	2361 (2.0)	566 (0.5)	881 (0.8)	275 (0.2)	310 (0.3)	47 (0.0)	4440 (3.9)
European	1461 (1.3)	371 (0.3)	558 (0.5)	200 (0.2)	187 (0.2)	36 (0.0)	2813 (2.4)
Non-European	3278 (2.8)	796 (0.7)	1386 (1.2)	470 (0.4)	456 (0.4)	78 (0.1)	6464 (5.6)
Maternal smoking habits							
No smoking	46 526 (40.4)	12 038 (10.5)	17 934 (15.6)	5556 (4.8)	5861 (5.1)	983 (0.9)	88 898 (77.2)
1–9 cigarettes/day	7790 (6.8)	2327 (2.0)	3671 (3.2)	1206 (1.0)	1205 (1.0)	204 (0.2)	16 403 (14.2)
≥ 10-cigarettes/day	4409 (3.8)	1379 (1.2)	2273 (2.0)	776 (0.7)	914 (0.8)	144 (0.1)	9895 (8.6)
APGAR score 5 minutes							
7–10	58 533 (50.8)	15 652 (13.6)	23 663 (20.5)	7408 (6.4)	7770 (6.7)	1209 (1.0)	114 235 (99.2)
< 7	192 (0.2)	92 (0.1)	215 (0.2)	130 (0.1)	210 (0.2)	122 (0.1)	961 (0.8)
Birth weight							
Normal	55 895 (48.5)	14 931 (13.0)	22 585 (19.6)	7010 (6.1)	7177 (6.2)	1129 (1.0)	108 727 (94.4)
Low or high for gestational age	2830 (2.5)	813 (0.7)	1293 (1.1)	528 (0.5)	803 (0.7)	202 (0.2)	6469 (5.6)
Father's highest education							
Compulsory	11 693 (10.2)	3331 (2.9)	5082 (4.4)	1690 (1.5)	1815 (1.6)	300 (0.3)	23 911 (20.8)
Two year secondary	22 830 (19.8)	6385 (5.5)	9969 (8.7)	3110 (2.7)	3329 (2.9)	536 (0.5)	46 159 (40.1)
Three year secondary	6439 (5.6)	1684 (1.5)	2605 (2.3)	767 (0.7)	810 (0.7)	144 (0.1)	12 449 (10.8)
University	16 242 (14.1)	3955 (3.4)	5645 (4.9)	1759 (1.5)	1783 (1.5)	317 (0.3)	29 701 (25.8)
Mother's highest education							
Compulsory	9015 (7.8)	2698 (2.3)	4328 (3.8)	1406 (1.2)	1518 (1.3)	267 (0.2)	19 232 (16.7)
Two year secondary	24 880 (21.6)	6892 (6.0)	10 522 (9.1)	3379 (2.9)	3535 (3.1)	573 (0.5)	49 781 (43.2)
Three year secondary	6725 (5.8)	1687 (1.5)	2527 (2.2)	751 (0.7)	795 (0.7)	129 (0.1)	12 614 (11.0)
University	17 420 (15.1)	4316 (3.7)	6267 (5.4)	1915 (1.7)	2028 (1.8)	351 (0.3)	32 397 (28.0)
Family type							
Married/cohabiting	47 390 (41.1)	12 447 (10.8)	18 600 (16.1)	5867 (5.1)	6096 (5.3)	1028 (0.9)	91 428 (79.4)
Not married/cohabiting	11 335 (9.8)	3297 (2.9)	5278 (4.6)	1671 (1.5)	1884 (1.6)	303 (0.3)	23 768 (20.6)

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run: three models × 2 for each outcome in which covariates were added stepwise using the method "enter". In the first set of analysis we included the variable number of nights hospitalized years 0–16 differentiated into five categories: 1 night, 2–5 nights, 6–10 nights, 11–50 nights, ≥ 51 nights. This enabled us to examine whether the relationship differed depending on how many nights the child had been hospitalized. In the second set of analysis we examined the timing of a hospitalization and its associated with school achievement. The 11–50 and ≥ 51 nights hospitalized were merged with the category ≥ 6 nights. Interaction terms for gender and hospitalization exposure years 0–16 and for the different age ranges were created and fitted into the models. Individuals not hospitalized served as a reference group in the regression models. Analyzes were performed using SPSS version 24.

Results

Table 1 presents the distribution of study variables across the study population. In total, 56 471 (49%) individuals had ever been hospitalized from their year of birth until their 16th year of

life. Table 2 presents the results of the multiple linear regression analysis using *overall grade points* as the outcome. The first crude model show that the grade points were lower for individuals that had been hospitalized 1 night (β = -7.05, $p < 0.001$), 2–5 nights (β = -10.27, $p < 0.001$), 6–10 nights (β = -14.64, $p < 0.001$), 11–50 nights (β = -19.84, $p < 0.001$) and ≥ 51 nights (β = -30.23, $p < 0.001$) as compared with their healthier counterparts. In the second model, all covariates were added. This attenuated the strength of the associations, however, even after adjustment for sociodemographic background factors and birth health status, the results clearly show that the overall grade points is significantly lower the longer the individual has been hospitalized. The third model, in which interaction terms were entered, reveal a significant interaction between hospitalization and gender: being a girl and having been hospitalized for 1 night (β = -2.13, $p < 0.05$), 2–5 nights (β = -2.19, $p < 0.05$), 6–10 nights (β = -2.98, $p < 0.05$) 11–50 nights (β = 3.82, $p < 0.01$) or ≥ 51 nights (β = - 10.28, $p < 0.01$) was significantly associated with lower overall grade points.

Table 3 presents the results of the second analysis using *overall grade points* as the outcome in which we specifically focused on age at illness. The three models in the table, one for each age period, are fully adjusted for all the covariates and clearly show that hospitalizations further up in the ages have greater consequences for the grade points. For all the interaction terms included, we only found significant associations between gender and hospitalization 2–5 nights (β = -8.37, $p < 0.001$) and ≥ 6 nights (β = - 9.57, $p < 0.001$) for ages 13–16.

Table 4 presents the results of the logistic regression analysis using *ineligibility for upper secondary education* as the outcome. The first unadjusted model show that being exposed to health problems requiring hospitalizations 1 night (OR = 1.25, CI = 1.17–1.33), 2–5 nights (OR = 1.34, CI = 1.27–1.42), 6–10 nights (OR = 1.51, CI = 1.76–2.03), 11–50 nights (OR = 1.89, CI = 1.76–2.03) or ≥ 51 nights (OR = 2.66, CI = 2.27–3.13) significantly increased the odds of ineligibility for upper secondary education: the longer hospital stay, the higher the odds for ineligibility. The second model show that, even after adjustment for all the covariates, hospitalization 1 night (OR = 1.17, CI = 1.10–1.25), 2–5 nights (OR = 1.21, CI = 1.15–1.28), 6–10 nights (OR = 1.33, CI = 1.22–1.44), 11–50 nights (OR = 1.66, CI = 1.54–1.79) or ≥ 51 nights (OR = 2.48, CI = 2.10–2.94) significantly increased the odds of ineligibility for upper secondary education ($p < 0.001$). The third model was adjusted for the interaction terms and revealed a non-significant interaction between hospitalizations and gender, except for hospitalization 11–50 nights ($p < 0.05$).

Table 5 presents the results of the second analysis using *ineligibility for upper secondary education* as the outcome, in which we specifically focused on age at illness. The three models in the table, one for each age period, are fully adjusted for all the covariates and show that hospitalizations further up in the ages are associated with higher odds ratios (OR) of ineligibility for upper secondary education. For all the interaction terms included, we only found significant associations for gender and hospitalization ≥ 6 nights for ages 0–6 ($p < 0.01$). Overall, the results suggested that if we consider school achievement in the three core subjects and ineligibility for secondary education, gender does not play a part. However, when considering school achievement across all school subjects as overall grade points, girls with health problems are associated with lower school achievements than boys with health problems.

Discussion

This study found that children with health problems were less successful in school. Even with the crude measure of health problems that we used in our study, i.e., hospitalizations, we discerned that Swedish children, in rather contemporary conditions, displayed lower school

Table 2. Linear regression models showing associations between hospitalizations and *overall grade points*, unstandardized beta-coefficients, standard error in parentheses.

	Model 1	Model 2	Model 3
Hospitalization age 0–16			
No hospitalizations	Ref.	Ref.	Ref.
1 night	-7.05 (.58)***	-3.45 (.52)***	-2.39 (.72)**
2–5 nights	-10.27 (.50)***	-5.00 (.44)***	-3.94 (.61)***
6–10 nights	-14.64 (.80)***	-8.26 (.72)***	-6.87 (.96)***
11–50 nights	-19.84 (.79)***	-12.82 (.71)***	-11.10 (.96)***
≥ 51 nights	-30.23 (1.99)***	-26.00 (1.79)***	-20.93 (2.54)***
Gender			
Boys		Ref.	Ref.
Girls		22.13 (.34)***	23.42 (.48)***
Maternal country of birth			
Sweden		Ref.	
Nordic		-3.04 (.90)**	-3.07 (.90)**
European		-.50 (1.13)	-.51 (1.13)
Non-European		-1.59 (.78)*	-1.66 (.78)*
Maternal smoking habits			
No smoking		Ref.	Ref.
1–9 cigarettes/day		-11.90 (.50)***	-11.89 (.50)***
≥ 10 cigarettes/day		-20.70 (.64)***	-20.70 (.64)***
Low or high birthweight			
No		Ref.	Ref.
Yes		-2.44 (.75)**	-2.43 (.75)***
APGAR score 5 minutes			
Normal		Ref.	Ref.
Low		-3.07 (1.96)	-3.00 (1.96)
Father's education			
Compulsory		Ref.	Ref.
Two year secondary		7.86 (.45)***	7.88 (.45)***
Three year secondary		20.11 (.64)***	20.11 (.64)***
University		29.69 (.54)***	29.67 (.54)***
Mother's education			
Compulsory		Ref.	Ref.
Two year secondary		16.51 (.51)***	16.52 (.51)***
Three year secondary		32.00 (.68)***	31.96 (.68)***
University		39.41 (.59)***	39.37 (.59)***
Family type			
Married/cohabiting		Ref.	Ref.
Not married/cohabiting		-15.66 (.42)***	-15.63 (.42)***
Municipal average			
overall grade points		0.54 (.1)***	0.54 (.1)***
Sex × 1 night			-2.13 (1.04)*
Sex × 2–5 nights			-2.19 (.89)*
Sex × 6–10 nights			-2.98 (1.44)*
Sex × 11–50 nights			-3.82 (1.43)**
Sex × ≥ 51 nights			-10.28 (3.57)**
Constant	211.30 (.26)***	61.18 (4.24)***	60.46 (4.24)***

(*Continued*)

Table 2. (Continued)

	Model 1	Model 2	Model 3
N	111 765	111 765	111 765
R^2	0.01	0.20	0.20

* = p < 0.05

** = p < 0.01

*** = p < 0.001, R^2 = Adjusted R Square.

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achievements as compared to their healthier counterparts. Consequently, health is a significant contributor to inequalities in education.

We found that girls who had been hospitalized in general had poorer achievements than boys, which raises several questions. The school performance difference can be explained and understood through norms and ideals, the social gender role constructs that manifest in schools and classrooms, which lead to teachers treating boys and girls differently [21]. Similar gender-driven mechanisms might exist in the case of health problems affecting girls and boys differently in their schooling. Examples from Sweden have shown that girls and boys differ in the problems they seek medical care for [48], how they cope with school-related stress [49] and how they perceive demands and appraisals in the school environment [50]. Despite possible explanations in the existing literature, we cannot within the framework of this study fully explain the gender differences detected in our findings, and hence they require further empirical analysis.

Table 3. Standardized beta-coefficients of *overall grade points* by hospitalization timing and gender interactions. Standard error in parentheses.

	Model 1a	Model 1b	Model 1c
1 night ages 0–6	-1.42 (.78)		
2–5 nights ages 0–6	-2.47 (.65)***		
≥ 6 nights ages 0–6	-5.65 (.80)***		
Gender × 1 night ages 0–6	-1.57 (1.14)		
Gender × 2–5 nights ages 0–6	-1.31 (.97)		
Gender × ≥ 6 nights ages 0–6	-1.68 (1.20)		
1 night ages 7–12		-3.80 (.94)***	
2–5 nights ages 7–12		-5.16 (1.02)***	
≥ 6 nights ages 7–12		-13.87 (1.65)***	
Gender × 1 night ages 7–12		-1.27 (1.42)	
Gender × 2–5 nights ages 7–12		0.52 (1.52)	
Gender × ≥ 6 nights ages 7–12		0.61 (2.47)	
1 night ages 13–16			-8.78 (1.09)***
2–5 nights ages 13–16			-8.61 (1.27)***
≥ 6 nights ages 13–16			-21.66 (1.83)***
Gender × 1 night			-3.04 (1.61)
Gender × 2–5 nights			-8.37 (1.78)***
Gender × ≥ 6 nights			-9.57 (2.49)***
Constant	65.44 (4.54)***	67.31 (4.54)***	68.62 (4.52)***
N	111 765	111 765	111 765
R^2	0.20	0.20	0.21

*** = $p < 0.001$. R^2 = Adjusted R Square. All models are fully adjusted for all the covariates.

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Table 4. Hospitalizations and odds ratios (OR) of *ineligibility for upper secondary education*. Confidence intervals (CI) in parentheses.

	Model 1	Model 2	Model 3
Hospitalization age 0–16			
No hospitalization	1	1	1
1 night	1.25 (1.17–1.33)***	1.17 (1.10–1.25)***	1.16 (1.07–1.27)***
2–5 nights	1.34 (1.27–1.42)***	1.21 (1.15–1.28)***	1.19 (1.10–1.27)***
6–10 nights	1.51 (1.27–1.42)***	1.33 (1.22–1.44)***	1.24 (1.11–1.38)***
11–50 nights	1.89 (1.76–2.03)***	1.66 (1.54–1.79)***	1.52 (1.38–1.69)***
≥ 51 nights	2.66 (2.27–3.13)***	2.48 (2.10–2.94)***	2.43 (1.93–3.05)***
Gender			
Boys		1	1
Girls		0.80 (.77-.84)***	0.77 (0.73–0.82)***
Maternal country of birth			
Sweden		1	1
Nordic		1.14 (1.03–1.26)**	1.15 (1.04–1.27)**
European		1.30 (1.03–1.26)***	1.30 (1.14–1.49)***
Non-European		1.29 (1.19–1.40)***	1.30 (1.19–1.41)***
Maternal smoking habits			
No smoking		1	1
1–9 cigarettes/day		1.44 (1.37–1.52)***	1.44 (1.37–1.52)***
≥ 10 cigarettes/day		1.71 (1.61–1.82)***	1.71 (1.60–1.82)***
Low or high birthweight			
No		1	1
Yes		1.17 (1.29–1.37)***	1.17 (1.07–1.27)***
APGAR score 5 minutes			
Normal		1	1
Low		1.09 (0.87–1.37)	1.08 (0.86–1.36)
Father's education			
Compulsory		1	1
Two year secondary		0.73 (0.69–0.76)***	0.73 (0.69–0.76)***
Three year secondary		0.49 (0.45–0.54)***	0.49 (0.45–0.54)***
University		0.38 (0.35–0.41)***	0.38 (0.35–0.41)***
Mother's education			
Compulsory		1	1
Two year secondary		0.59 (0.56–0.62)***	0.59 (0.56–0.62)***
Three year secondary		0.32 (0.30–0.36)***	0.33 (0.30–0.36)***
University		0.32 (0.29–0.34)***	0.32 (0.30–0.35)***
Family type			
Married/cohabiting		1	1
Not married/cohabiting		1.58 (1.51–1.66)***	1.58 (1.50–1.65)***
Municipal average		0.98 (0.98–0.98)***	0.98 (0.98–0.98)***
overall grade points			
Sex × 1 night			1.00 (0.88–1.47)
Sex × 2–5 nights			1.04 (0.93–1.16)
Sex × 6–10 nights			1.17 (0.99–1.38)
Sex × 11–50 nights			1.21 (1.04–1.41)*
Sex × ≥ 51 nights			1.04 (0.74–1.46)
Constant	-2.48 (.01)***	1.88 (.27)***	1.90 (.27)***

(*Continued*)

Table 4. (Continued)

	Model 1	Model 2	Model 3
N	111 765	111 765	111 765
R^2	0.009	0.11	0.11

* = p < 0.05

** = p < 0.01

*** = p < 0.001, R^2 = Nagelkerke R Square.

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Regarding our third aim—to investigate how the timing of a health problem affects later school achievement—we learned that individuals who were exposed to hospitalizations closer to the actual grading suffered a poorer outcome. Thus, there seems to be a timing effect. In our study, junior high school was found to be a critical period regarding the effect on compulsory school grades of exposure to health problems requiring hospitalization. Although the years prior to formal schooling are important concerning school readiness [51], it seems easier to recuperate from diseases during the infant years. However, when already in school, especially close to actual grading, disruptions like exposure to health problems have a greater negative impact on school achievement. Good health can be seen as a buffer against life stressors [52] and junior high school is a period often associated with various life stressors, educational progress and transition into adolescence. Thus, this period is understandably critical.

Table 5. Hospitalization timing, gender interactions and odds ratios (OR) for *ineligibility for upper secondary education*. Confidence intervals in parentheses.

	Model 1a	Model 1b	Model 1c
1 night ages 0–6	1.06 (0.97–1.16)		
2–5 nights ages 0–6	1.12 (1.04–1.21)**		
≥ 6 nights ages 0–6	1.21 (1.11–1.32)***		
Gender × 1 night ages 0–6	1.02 (0.88–1.16)		
Gender × 2–5 nights ages 0–6	1.03 (0.92–1.16)		
Gender × ≥ 6 nights ages 0–6	1.22 (1.07–1.39)**		
1 night ages 7–12		1.21 (1.09–1.34)***	
2–5 nights ages 7–12		1.22 (1.09–1.37)***	
≥ 6 nights ages 0–6		1.55 (1.31–1.82)***	
Gender × 1 night ages 7–12		0.97 (0.82–1.14)	
Gender × 2–5 nights ages 7–12		0.89 (0.75–1.07)	
Gender × ≥ 6 nights ages 7–12		1.03 (0.90–1.33)	
1 night ages 13–16			1.34 (1.19–1.51)***
2–5 nights ages 13–16			1.49 (1.31–1.70)***
≥ 6 nights ages 13–16			2.10 (1.77–2.49)***
Gender × 1 night ages 0–6			1.11 (0.93–1.33)
Gender × 2–5 nights ages 7–12			1.03 (0.86–1.25)
Gender × ≥ 6 nights ages 13–16			1.09 (0.86–1.38)
Constant	1.81 (.25)***	1.74 (.25)***	1.69 (.25)***
N	111 765	111 765	111 765
R^2	0.10	0.11	0.11

** = $p < 0.01$

*** = $p < 0.001$. R^2 = Nagelkerke R Square. All models are fully adjusted for all the covariates.

https://doi.org/10.1371/journal.pone.0208116.t005

Limitations of the study should be mentioned. Hospitalizations as a measure captures only general non-specific health problems. Detailed information from the NPR, such as diagnostic type, would allow us to access specifics of a health problem, especially when trying to find reasons for the observed gender differences, which is imperative. Grading in compulsory school only occurred in grade 9 for this cohort, outcome measures at several occasions would have improved the study. Moreover, other individuals who suffer from other disabilities/impairments but who did not receive similar care (i.e. requiring hospitalization) and who we could not account for may exist in our sample. Further, the age groupings 0–6, 7–12 and 13–16 describe different lengths of time and thus their coefficients are not directly comparable.

The main strengths of our study are the high quality datasets; the multiple sources of linked data, in particular access to the MBR which allowed us to control for health selection that might occur at birth. This enabled us to observe a whole cohort of individuals from prior to birth until graduation from compulsory school. In addition, the study used two different educational achievement variables, where overall grade points indicate differences in levels of school achievement while eligibility for continuation to upper secondary education indicate problems of completing education at all.

In conclusion, this study found that health problems, measured as hospitalizations, was significantly association with lower school achievements among Swedish children. Girls exposed to hospitalizations had in general poorer school achievements compared to boys. Support services should pay particular attention to the needs of young people when they suffer health problems that lead to hospitalizations during junior high school as this seemingly is a critical period in relation to their final achievement at compulsory school.

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