The Population Impact of Childhood Health Conditions on Dropout from Upper-Secondary Education

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Objectives To quantify how large a part of educational dropout is due to adverse childhood health conditions and to estimate the risk of dropout across various physical and mental health conditions.

Study design A registry-based cohort study was conducted on a 20% random sample of Finns born in 1988-1995 (n = 101 284) followed for school dropout at ages 17 and 21. Four broad groups of health conditions (any, somatic, mental, and injury) and 25 specific health conditions were assessed from inpatient and outpatient care records at ages 10-16 years. We estimated the immediate and more persistent risks of dropout due to health conditions and calculated population-attributable fractions to quantify the population impact of childhood health on educational dropout, while accounting for a wide array of sociodemographic confounders and comorbidity.

Results Children with any health condition requiring inpatient or outpatient care at ages 10-16 years were more likely to be dropouts at ages 17 years (risk ratio 1.71, 95% CI 1.61-1.81) and 21 years (1.46, 1.37-1.54) following adjustment for individual and family sociodemographic factors. A total of 30% of school dropout was attributable to health conditions at age 17 years and 21% at age 21 years. Mental disorders alone had an attributable fraction of 11% at age 21 years, compared with 5% for both somatic conditions and injuries. Adjusting for the presence of mental disorders reduced the effects of somatic conditions.

Conclusions More than one fifth of educational dropout is attributable to childhood health conditions. Early-onset mental disorders emerge as key targets in reducing dropout. *(J Pediatr 2018;■■:■■-■■).*

Adolescents with no postcompulsory education are at particular risk of cumulative disadvantage through poor health, poverty, and unemployment later in life.[1-4] Early-life health is a key determinant of educational attainment,[1,5-7] but the contribution of health on school dropout at the population level is unknown. It has been suggested that poor health could disturb educational careers by delaying cognitive development, shifting focus away from long-term goals such as education and employment, and disengaging children from their school and peers through increased negative interactions, stigmatization, and missed school days.[5,8-10]

Previous research has found health conditions to predict worse educational outcomes, particularly for mental disorders,[11-22] whereas evidence on specific somatic conditions is mixed.[23-40] Overall, the scarce comparable evidence indicates mental disorders to be more significant than physical conditions in explaining educational disparities.[41-43] Despite their high prevalence, childhood injuries have been largely neglected in studies of educational outcomes.[44,45] Relying mostly on limited, typically self-reported health measures,[7,46] or on clinical samples, previous studies have been unable to combine a wider perspective of health to assessment of specific conditions, or to account for comorbidity.[7,47,48] According to systematic reviews, most previous results are from the US, which makes their applicability to other educational and welfare systems uncertain.[7,49] Most importantly, with small, nonrepresentative samples, it has been impossible to evaluate how much of dropout is attributable to health conditions at the population level.

This study uses large, population-based cohort data to assess the immediate (age 17 years) and more persistent (age 21 years) consequences of childhood health conditions on dropout from upper-secondary education. Using administrative data on inpatient and outpatient care, we estimate whether having any condition, a somatic condition, a mental disorder, or an injury at ages 10-16 years predicts educational dropout and quantify the population impact of these conditions by calculating population-attributable fractions (PAFs). We also assess the effects of 25 specific conditions while accounting for their comorbidity. Given that both poor childhood health and weak educational achievement are overrepresented in socially disadvantaged families[6,50,51] we control for a large number of sociodemographic confounders.

PAF	Population-attributable fraction
RR	Risk ratio

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Methods

We used a nationally representative 20% random sample of households in mainland Finland with at least 1 child aged 0-14 at the end of 2000. This sample comprised annual, individual-level measurements from several national registers covering all household members spanning the years 1987-2012. Statistics Finland combined the data from different registers with the personal identification numbers assigned to all residents in Finland (permission TK-53-525-11). We included children born between 1988 and 1995 (n = 102 998), excluding those who had received treatment for intellectual disabilities (*International Statistical Classification of Diseases and Related Health Problems, 10th edition*, codes F70-F79). We also excluded children who had emigrated or died by age 17 years (n = 952), after which the final study sample consisted of 101 284 children. Because 2012 was the last available measurement year, we used a subsample of these children to analyze schooling status at age 21 years (birth cohorts 1988-1991, n = 50 327).

Measures

Finnish children attend a compulsory 9-year comprehensive school that usually begins in the year the child turns 7 and ends in the year he or she turns 16. Virtually all children (>99.5%) receive a comprehensive-school certificate during their compulsory education.[52] Most school-leavers continue to the upper-secondary level that divides into an academic and a vocational track and lasts 2-4 years after comprehensive school, although some enroll for voluntary additional basic education or preparatory courses for upper-secondary education, both lasting 12 months at the most.[53] We chose the age of 17 years as the earliest measurement point for dropout because at that age even those with 1 gap year or prolonged compulsory schooling ought to have begun their upper-secondary studies. Meanwhile, we chose age 21 years as the final measurement point because obtaining an upper-secondary diploma becomes increasingly unlikely after this age.[54]

We used information provided by Statistics Finland to form the outcome variable of the study, ie, dropout from upper-secondary education, and defined a "dropout" dummy that took the value 1 if the person was not enrolled in any institution offering upper-secondary education at the given age, did not receive student financial aid during that year, and had not obtained an upper-secondary diploma by that age. Thus measured, the proportion of dropouts increases by age as some people start upper-secondary education but never finish.

Health indicators were based on visits to inpatient hospital care (1995-2011) and outpatient specialized services (1998-2011), derived from the Finnish Hospital Discharge Register. We formed indicators of health conditions expressing whether the person had at least 1 inpatient or outpatient visit with a corresponding primary *International Statistical Classification of Diseases and Related Health Problems, 10th edition*, code at ages 10-16 years. The use of a 7-year age span reduces both random and systematic (eg, due to differences in treatment seeking) variation in the detection of health conditions. Moreover, ages 10-16 years capture a salient stage of life with respect to educational careers and precede the measurement of dropout at ages 17 and 21 years.

Table I (available at www.jpeds.com) gives the complete list of the diagnostic codes included in the study. First, we identified 3 broad groups of health conditions, ie, somatic, mental, and injury, as well as a general group of any condition, which included all of these groups. Second, based on population prevalence and previous significance in the previous literature, we identified 14 specific somatic conditions, 9 mental disorders, and 2 types of injuries. Within somatic conditions, we included allergy, asthma, cancer, cerebral palsy, celiac disease, congenital heart disease, dorsopathy, epilepsy, inflammatory bowel disease, migraine and other headache syndromes, rheumatoid arthritis, severe infection (ie, pneumonia, meningitis, and sepsis), visual or hearing impairment, and type 1 diabetes. The mental disorders included attention deficit-hyperactivity disorder, anxiety, conduct disorder, eating disorders, pervasive developmental disorders (eg, autism), specific developmental disorders (eg, of speech and language), unipolar depression, psychosis, and substance abuse disorder. Of the injuries, we examined fractures and intracranial injuries separately.

We controlled for individual-level factors (sex, birth year, birth quarter, and maternal age at birth) that might be associated with both the risk of health conditions (or seeking treatment for them) and the risk of school dropout. We also adjusted for several family background–related factors (household income quintile, highest parental education, family type, immigrant status, number of children <18 years living in the same household, persons per room excluding kitchen). Furthermore, we controlled for region of residence and type of municipality to take account of any regional differences in the prevalence of illnesses, access to treatment, and educational opportunities. All control variables were derived from the longitudinal population data file of Statistics Finland. We measured the family- and regional-level characteristics at ages 10-15 years because virtually all Finnish children in this age range still live with a parent or a guardian.[55] We treated these measurements as 6-year averages/modes to control for annual fluctuations. **Table II** (available at www.jpeds.com) shows the classifications and distributions of all the control variables.

Statistical Analyses

We ran Poisson regression models with robust SEs to estimate risk ratios (RR) of dropout between children with and without adverse health conditions at ages 10-16 years.[56] We took family-level clustering into account by using generalized estimating equations and an exchangeable working correlation structure.[57] We chose the robust Poisson method instead of log-binomial regression, given the convergence issues with the latter.[57] In addition, we calculated PAFs to quantify the contribution of different health conditions at the population level. Different formulas yield the crude and adjusted PAFs:

$$Crude\ PAF = P_T(RR_C - 1)/(1 + P_T(RR_C - 1))$$

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where P_T is the prevalence of the health condition at ages 10-16 years in the total sample, RR_C is the crude risk ratio;

$$Adjusted\ PAF = P_D((RR_A - 1)/RR_A)$$

where P_D is the prevalence of the health conditions at ages 10-16 years among dropouts, and RR_A is the risk ratio adjusted for confounding factors.[58] In our application, the PAF estimate the percentage decline in dropout if the health condition were eliminated, assuming the effects causal. We carried out all analyses with Stata 14.2 (StataCorp LLC, College Station, Texas).

Results

The RRs of Dropout by the Presence of Health Conditions

The prevalence of dropout from upper-secondary education increased from 4.8% at age 17 years to 9.2% at age 21 years (**Table III**). Similar figures have been shown in a report published by the Organisation for Economic Co-operation and Development, where the Finnish dropout rates represent the average level of Northern and Central European countries.[4] At each of the examined ages and for both sexes, dropout was more common among youth with any childhood health condition, a somatic condition, a mental disorder, or an injury. The broad categories of any condition, a somatic condition, a mental disorder, and an injury were all associated with dropout at ages 17 years (**Table IV**) and 21 years (**Table V**), with mental disorders showing the greatest RRs. The differences between crude and adjusted RRs were the largest for mental disorders (4.06 vs 3.18 at age 17 years and 2.78 vs 2.18 at age 21 years), whereas somatic conditions showed smaller relative reductions (1.31 vs 1.27 at age 17 years and 1.20 vs 1.15 at age 21 years). The RRs related to any condition, a somatic condition, and a mental disorder were smaller at age 21 years than at age 17 years, and the reverse was the case for injuries.

Table III. The prevalence (%) of dropout from upper-secondary education at ages 17 and 21 years by sex and the presence of adverse health conditions at ages 10-16 years*

Health conditions	Age 17 years	Age 21 years
Girls		
Any		
No	3.1	5.0
Yes	6.3	9.4
Somatic		
No	4.3	6.5
Yes	5.9	9.0
Mental		
No	3.8	6.3
Yes	15.6	20.2
Injury		
No	4.7	7.1
Yes	6.0	9.5
Boys		
Any		
No	3.3	8.6
Yes	5.9	12.5
Somatic		
No	4.4	10.4
Yes	5.6	11.6
Mental		
No	3.7	9.6
Yes	16.6	25.6
Injury		
No	4.7	10.1
Yes	5.4	13.6
Total	4.8	9.2

*All differences between children with and without adverse health conditions significant at $P < .001$ except for injury among girls at age 17 ($P = .002$) and somatic conditions among boys at age 21 ($P = .003$).

Based on the adjusted RRs of specific health conditions, epilepsy, congenital heart disease, and severe infection showed strong associations at both ages. Cerebral palsy had the largest RR, but the estimation is uncertain due to small number of cases. Cancer and visual or hearing impairment exhibited large RRs at age 17 years, but at age 21 years their relationships with dropout status virtually vanished. Within the group of mental disorders, psychosis presented the largest risk at both ages, and the other individual conditions also showed strong associations, except for eating disorders at age 21 years. The specific health conditions generally showed a similar pattern of diminishing RRs for school dropout by increasing age, as did the broad categories.

Sex Differences and Comorbidity

At age 17 years, there were no sex differences in the RRs adjusted for control variables, whereas at age 21 years the RRs related to any condition, a somatic condition, and a mental disorder were larger for girls than for boys (**Figure 1**, Model 2). Adjusting for other health conditions at ages 10-16 (Model 3) removed the association between somatic conditions and dropout among boys but not among girls. The RRs related to mental disorders became only slightly smaller when adjusted for somatic conditions and injuries, and they retained their sex difference. Childhood injuries remained associated with dropout among both boys and girls at age 21 years. A sensitivity analysis that omitted injuries (not presented) showed virtually similar reductions in the RRs of somatic conditions and mental disorders. To investigate potential cohort effects behind differences at ages 17 and 21 years, we reran the analysis presented in **Figure 1** using the smaller subsample of cohorts present at both ages (**Figure 2**; available at www.jpeds.com). In these analyses, the uncertainty of estimation at age 17 years was larger, but the effect sizes remained practically the same.

Table VI (available at www.jpeds.com) presents a similar comorbidity analysis for the specific health conditions. Almost all statistically significant (at the $P < .05$ level) RRs retained their significance, although this analysis may be more conservative due to multicollinearity. As exceptions, dorsopathy and eating disorders were no longer distinctively associated with dropout. Congenital heart disease, epilepsy, severe infection, and cerebral palsy were the only somatic conditions that had clear associations with dropout following adjustment for sociodemographic covariates and comorbid conditions. Mental disorders showed larger reductions in RRs than somatic conditions or injuries did, following adjustment for comorbid

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Table IV. Crude and adjusted (for sex and control variables) RRs* (with 95% CI) and PAF of dropout from upper-secondary education at age 17 years by the presence of health conditions† at ages 10-16 years (n = 101 284)‡

Health conditions	Prevalence, %	Prevalence among cases, %	Crude RR	95% CI	Adjusted RR	95% CI	Crude PAF	Adjusted PAF
Any condition	57.61	72.02	**1.84**	(1.73-1.95)	**1.71**	(1.61-1.81)	32.55	29.82
Somatic conditions	36.08	42.82	**1.31**	(1.24-1.38)	**1.27**	(1.21-1.34)	9.97	9.20
Asthma	4.59	5.16	**1.13**	(1.00-1.28)	1.11	(0.98-1.25)	0.60	0.50
Allergy	3.33	3.20	0.97	(0.83-1.13)	0.96	(0.82-1.11)	–0.10	-0.14
Dorsopathy	2.00	2.57	**1.35**	(1.14-1.59)	**1.34**	(1.14-1.58)	0.69	0.65
Migraine or severe headaches	1.49	2.43	**1.64**	(1.37-1.95)	**1.55**	(1.31-1.84)	0.94	0.87
Severe infection	0.94	1.55	**1.66**	(1.34-2.05)	**1.66**	(1.34-2.06)	0.62	0.62
Type 1 diabetes	0.78	0.84	1.06	(0.78-1.44)	1.08	(0.81-1.46)	0.05	0.06
Visual or hearing impairment	0.78	1.94	**2.47**	(2.04-2.99)	**2.24**	(1.84-2.73)	1.14	1.07
Epilepsy	0.78	2.28	**2.88**	(2.40-3.45)	**2.77**	(2.32-3.31)	1.44	1.46
Congenital heart disease	0.55	1.43	**2.57**	(2.06-3.21)	**2.44**	(1.94-3.07)	0.86	0.84
Rheumatoid arthritis	0.43	0.55	1.26	(0.87-1.84)	1.29	(0.89-1.85)	0.11	0.12
Celiac disease	0.28	0.35	1.14	(0.70-1.86)	1.32	(0.83-2.10)	0.04	0.09
Inflammatory bowel disease	0.23	0.26	1.11	(0.66-1.88)	1.31	(0.78-2.20)	0.03	0.06
Cancer	0.21	0.43	**2.13**	(1.42-3.18)	**2.09**	(1.38-3.16)	0.24	0.22
Cerebral palsy	0.16	0.79	**4.98**	(3.74-6.64)	**4.40**	(3.18-6.09)	0.63	0.61
Other somatic conditions	28.49	35.21	**1.34**	(1.26-1.41)	**1.29**	(1.22-1.36)	8.72	7.88
Mental disorders	8.78	29.20	**4.06**	(3.83-4.32)	**3.18**	(2.98-3.38)	21.20	20.01
Unipolar depression	2.12	8.17	**3.93**	(3.57-4.32)	**3.04**	(2.75-3.35)	5.84	5.48
Specific developmental disorder	1.68	5.71	**3.30**	(2.93-3.72)	**2.66**	(2.37-2.99)	3.73	3.57
Conduct disorder	1.39	7.38	**5.18**	(4.68-5.74)	**3.11**	(2.80-3.46)	5.50	5.01
Anxiety	1.19	4.61	**3.74**	(3.29-4.24)	**3.07**	(2.71-3.48)	3.15	3.11
ADHD	0.74	2.55	**3.35**	(2.82-3.99)	**2.44**	(2.05-2.90)	1.71	1.50
Eating disorder	0.58	0.86	**1.49**	(1.11-2.01)	**1.56**	(1.16-2.10)	0.28	0.31
Substance abuse disorder	0.54	1.79	**3.12**	(2.55-3.83)	**2.40**	(1.98-2.92)	1.13	1.05
Pervasive developmental disorder	0.43	1.87	**4.31**	(3.57-5.22)	**3.71**	(3.02-4.56)	1.41	1.37
Psychosis	0.33	2.00	**5.97**	(5.01-7.10)	**4.75**	(3.94-5.72)	1.61	1.58
Other mental disorders	3.26	11.21	**3.52**	(3.23-3.83)	**2.53**	(2.32-2.76)	7.58	6.78
Injury	17.86	20.68	**1.18**	(1.11-1.27)	**1.15**	(1.08-1.23)	3.19	2.69
Fracture	8.98	9.94	**1.11**	(1.02-1.22)	1.08	(0.99-1.18)	1.02	0.73
Intracranial injury	1.44	2.00	**1.37**	(1.13-1.66)	**1.31**	(1.09-1.59)	0.53	0.48
Other injury	9.97	12.17	**1.23**	(1.13-1.34)	**1.18**	(1.09-1.28)	2.27	1.88

*RRs in bold are statistically significant at the .05 level.
†Separate models for different health conditions.
‡Population born in 1988-1995.

conditions. Table VI also presents a multimorbidity analysis, which shows increasing risks of dropout with increasing number of health conditions.

Proportions of Dropout Attributable to Health Conditions

The adjusted PAFs for health conditions requiring inpatient or outpatient care at ages 10-16 were up to 30% at age 17 years and 21% at age 21 years, whereas up to 20% and 11% of dropout at these ages was attributable to mental disorders alone (Tables IV and V). Some conditions, such as psychosis and pervasive developmental disorder, with large RRs of dropout for affected individuals made a minor contribution at the population level due to their rarity. From this perspective, conduct disorders and unipolar depression emerged as the most significant population-level contributors to dropout.

Discussion

We show that childhood health conditions are key contributors to dropout from upper-secondary education at the levels of both RR and PAF. Children who had a health condition requiring inpatient or outpatient care at ages 10-16 years, the stage of life at which educational careers start to diverge, were 71% more likely to drop out at age 17 years and, to a slightly smaller extent, even at age 21 years. These patterns were particularly pronounced for mental disorders, but somatic conditions and injuries also substantially increased the risk of educational dropout. At the population level, childhood health conditions were significant contributors to dropout, with attributable fractions of up to 21% for all health conditions combined and 11% for mental disorders alone at age 21 years. Although family social conditions may be significant predictors of both childhood health and educational attainment, they explained only a modest part (around one fifth at most) of the relationship between childhood health conditions and school dropout.

The present study benefitted from a large population-based sample, which enabled us to evaluate both the immediate and the more persistent educational consequences of several childhood health conditions while controlling for a large number of sociodemographic confounders. The use of register-based data helped to avoid the common problems with longitudinal survey studies, such as attrition, nonresponse, preferential reporting, and recall bias.[48] The healthcare registers we used have

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Table V. Crude and adjusted (for sex and control variables) RRs* (with 95% CI) and PAF of dropout from upper-secondary education at age 21 years by the presence of health conditions† at ages 10-16 years (n = 50 327)‡

Health conditions	Prevalence, %	Prevalence among cases, %	Crude RR	95% CI	Adjusted RR	95% CI	Crude PAF	Adjusted PAF
Any condition	56.85	68.28	**1.61**	(1.52-1.71)	**1.46**	(1.37-1.54)	25.80	21.41
Somatic conditions	35.56	40.03	**1.20**	(1.14-1.27)	**1.15**	(1.09-1.22)	6.66	5.34
Asthma	4.74	5.25	1.12	(0.99-1.27)	1.02	(0.91-1.16)	0.57	0.13
Allergy	3.23	2.97	0.94	(0.80-1.10)	0.91	(0.78-1.07)	–0.20	–0.29
Dorsopathy	1.88	1.93	1.01	(0.82-1.23)	1.07	(0.88-1.30)	0.01	0.13
Migraine or severe headaches	1.37	1.73	**1.25**	(1.01-1.54)	1.21	(0.98-1.49)	0.34	0.30
Severe infection	0.96	1.34	**1.41**	(1.11-1.78)	**1.37**	(1.08-1.73)	0.39	0.36
Type 1 diabetes	0.71	0.82	1.18	(0.87-1.59)	1.09	(0.82-1.47)	0.12	0.07
Visual or hearing impairment	0.73	0.87	1.21	(0.91-1.62)	1.08	(0.81-1.44)	0.15	0.07
Epilepsy	0.83	1.41	**1.67**	(1.33-2.10)	**1.60**	(1.28-2.01)	0.56	0.53
Congenital heart disease	0.49	0.76	**1.55**	(1.15-2.10)	**1.47**	(1.08-2.01)	0.27	0.24
Rheumatoid arthritis	0.41	0.48	1.17	(0.78-1.74)	1.29	(0.88-1.89)	0.07	0.11
Celiac disease	0.21	0.20	0.93	(0.49-1.76)	1.05	(0.56-1.98)	–0.01	0.01
Inflammatory bowel disease	0.22	0.17	0.76	(0.38-1.52)	0.91	(0.47-1.78)	–0.05	–0.02
Cancer	0.18	0.15	0.81	(0.38-1.71)	0.84	(0.40-1.79)	–0.03	–0.03
Cerebral palsy	0.16	0.26	1.64	(0.96-2.80)	1.73	(0.98-3.07)	0.10	0.11
Other somatic conditions	28.03	32.57	**1.23**	(1.16-1.30)	**1.18**	(1.11-1.24)	5.94	4.87
Mental disorders	7.96	19.90	**2.78**	(2.61-2.98)	**2.18**	(2.04-2.33)	12.44	10.76
Unipolar depression	1.78	4.71	**2.63**	(2.33-2.97)	**2.26**	(2.00-2.56)	2.82	2.63
Specific developmental disorder	1.63	3.38	**2.07**	(1.79-2.40)	**1.57**	(1.36-1.81)	1.72	1.22
Conduct disorder	1.24	5.51	**4.37**	(3.92-4.86)	**2.64**	(2.36-2.94)	4.01	3.42
Anxiety	0.84	2.28	**2.69**	(2.27-3.19)	**2.43**	(2.06-2.86)	1.40	1.34
ADHD	0.48	1.41	**2.86**	(2.30-3.57)	**1.89**	(1.51-2.37)	0.89	0.66
Eating disorder	0.47	0.54	1.16	(0.80-1.67)	1.44	(1.00-2.07)	0.07	0.16
Substance abuse disorder	0.53	1.78	**3.20**	(2.67-3.85)	**2.37**	(1.99-2.83)	1.16	1.03
Pervasive developmental disorder	0.35	0.89	**2.48**	(1.88-3.27)	**1.90**	(1.42-2.53)	0.52	0.42
Psychosis	0.29	0.95	**3.14**	(2.41-4.08)	**2.74**	(2.13-3.52)	0.62	0.60
Other mental disorders	2.95	7.52	**2.60**	(2.36-2.87)	**1.96**	(1.78-2.16)	4.51	3.69
Injury	17.55	23.09	**1.39**	(1.30-1.48)	**1.26**	(1.18-1.34)	6.39	4.75
Fracture	8.74	10.95	**1.27**	(1.16-1.38)	**1.13**	(1.04-1.23)	2.28	1.30
Intracranial injury	1.36	1.97	**1.44**	(1.19-1.75)	**1.29**	(1.07-1.55)	0.60	0.44
Other injury	9.85	14.12	**1.48**	(1.37-1.60)	**1.34**	(1.25-1.45)	4.54	3.62

*RRs in bold are statistically significant at the .05 level.
†Separate models for different health conditions.
‡Population born in 1988-1995.

been validated on account of their accuracy and full national coverage[59]: we were able to observe care visits comprehensively and to separate the different diagnoses reliably.

However, because we only had access to records on inpatient hospital care and outpatient specialized services, we were unable to identify children who did not seek treatment or were not recognized by providers of primary care and thus referred for further treatment. This problem may concern mental disorders more than somatic conditions or injuries, but even in the case of mental illnesses, the fact that school healthcare is free of charge for all pupils in Finland and includes 3 extensive health checks during compulsory schooling[60] diminishes both the risk of adverse health conditions going totally unnoticed and the role of parents in seeking help. Given that the Finnish healthcare system is founded on universal government-subsidized services,[60] children with severe health conditions were likely to have received treatment during our 7-year measurement period.

In any case, our approach to measurement limits the generalizability of our results to diagnoses given by specialists, which capture more severe health conditions and are likely to show larger effects than less severe conditions. Two potentially relevant groups that are not covered and could be examined in future studies are children who are often ill but not seriously and children who have health conditions in early childhood. Finally, although we were able to control for a host of sociodemographic confounders, future studies could move forward by taking into account psychological factors[9] and the common genetic factors behind health and education.[61]

Using routinely collected register data with detailed health measures, we show that the significance of health-related selection to education may have been underestimated in previous studies that have, for several decades, mainly relied on self-reported health measures, health behaviors, and proxies for health status such as height.[7,10,46] We demonstrate the particular significance of early-onset mental and psychosocial problems.[41-43] Furthermore, in showing non-negligible associations between somatic conditions and dropout, our results contradict some previous research that did not observe any relationship between physical health and educational careers.[41,43] A likely explanation for these differences is that our study was based on inpatient hospital care and outpatient specialized services, which treat more severe cases on average, whereas the earlier studies measured self-reported chronic conditions[41] and general practitioner consultations in smaller samples.[43] Thus, despite the convincing evidence that childhood

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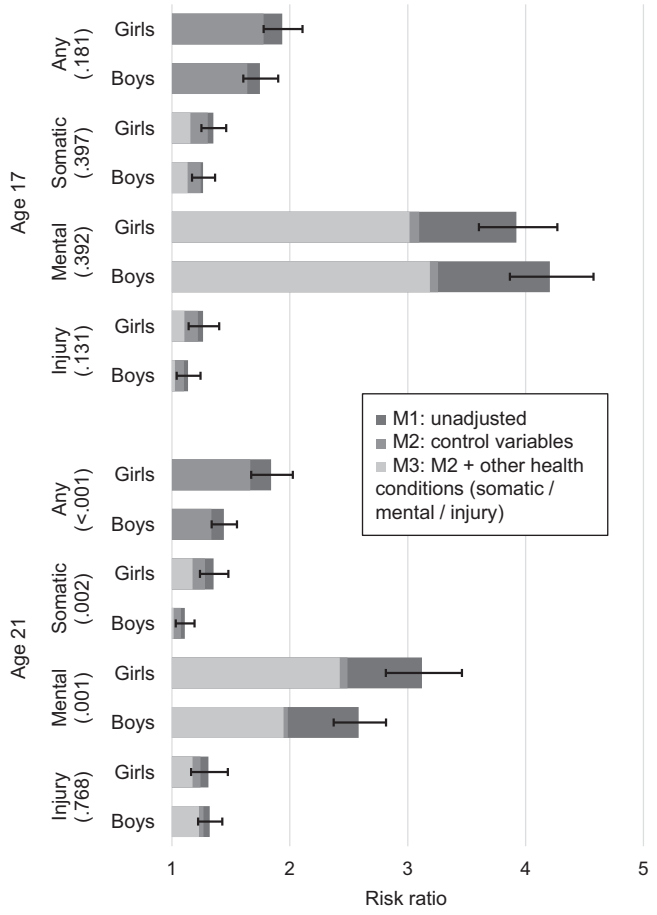

Figure 1. Crude and adjusted RRs of dropout from upper-secondary education at ages 17 years (n = 101 284) and 21 years (n = 50 327) according to the presence of health conditions at ages 10-16 years by sex and the type of health condition: 95% CIs for Model 1 (M1) and *P* values (in parentheses) for the sex difference in Model 2 (M2).

psychological problems may have more detrimental effects on long-term socioeconomic trajectories than physical health problems,[62] the contribution of severe somatic conditions and major injuries should not be neglected.

With our population data, we were able to evaluate how large a part of school dropout is attributable to health conditions at the population level, assuming the effects of health conditions causal. Previous evidence on this is scarce, although 1 study estimated that 46% of high-school noncompletion in the US could be attributable to mental disorders.[63] In our study, however, even the unadjusted attributable fractions were smaller (20%-30%), probably due to both differences in the measurement of dropout (we classified enrolled persons as nondropouts) and differences in the measurement of mental disorders (diagnostic interviews in the US).

Few earlier studies have simultaneously assessed the effects of different types of somatic health conditions. Our finding that the most prevalent condition of those included in this study, asthma, was not associated with dropout is in line with previous results.[27,28] We also show nonexistent associations for diabetes,[30,31] although 1 earlier study from the US reported increased high-school dropout rates and decreased years of schooling among persons with diabetes.[29] Inflammatory bowel disease was not associated with dropout in our study, and previous studies have also hinted that the disease might have more detrimental effects on labor market outcomes than education.[34,35] Our analysis further indicated that cancer was associated with dropout at age 17 years but not at age 21 years: most previous studies on childhood cancer also have shown that the long-term educational consequences are restricted to central nervous system tumors and leukemia.[36-40] Our results nevertheless indicate that cancer may disturb the transition to upper-secondary education, which could have other negative long-term consequences.

We found no substantial differences in the associations of externalizing (conduct disorder, attention deficit-hyperactivity disorder, and substance abuse) and internalizing (unipolar depression and anxiety) spectrum disorders with dropout when we estimated the RRs of different mental disorders separately. In contrast, mental disorders are often comorbid,[64,65] so that the effect of one condition could reflect the composite effects of several conditions. Although all the risk ratios became weaker following adjustment for comorbid mental disorders, eating disorder was the only one to lose its independent effect. Some previous studies have implied that the effect of internalizing spectrum disorders might even disappear after taking externalizing into account,[15,66] but this was not the case in our study. However, conduct disorder showed the largest 2-fold risk ratio in the simultaneous analysis, a finding that is consistent with its significant role as reported in previous research.[15,67-69] The fact that mental disorders had strong associations even at age 21 years might be attributable to their persistence and recurrence, as is particularly typical of adolescent-onset mood disorders.[70,71]

Previous studies also imply that coping with chronic somatic conditions induces psychosocial problems in children; hence, mental disorders could mediate the associations between somatic conditions and dropout.[26,42] Our comorbidity analysis showed some interrelation between the groups of somatic conditions, mental disorders, and injuries, although adjusting for other groups of health conditions generally led to rather small reductions in the RRs. Nevertheless, the fact that the association between somatic conditions and dropout among boys vanished at age 21 years following adjustment for mental disorders could be a sign of impaired psychosocial functioning, although our measurement approach did not identify the temporal order of different conditions.

A previous Canadian study showed that major injuries in adolescence predicted delays in the educational career at age 17 years[44]: our study showed that the association with dropout extended to age 21 years. Traumatic brain injuries seem to be associated with impaired psychosocial functioning and educational skills,[45,72] but children with poor school performance also may be more prone to injury.[73] This kind of reverse causality or confounding due to unobserved psychological characteristics may well be significant in explaining the effects of

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milder injuries, but unfortunately we were unable to control for it.

The few earlier studies that have tested for the presence of sex differences in health-schooling relationships present conflicting results.[11,13,47,48] Our results strengthen the evidence that both somatic conditions and mental disorders are more significant predictors of dropout among girls than among boys. It is nevertheless difficult to judge whether these differences have a causal explanation or whether female dropouts are a more selected population in general. Meanwhile, it is worth noting that in absolute terms increases in dropout for mental disorders were larger for boys (**Table III**), which implies that a hypothetical eradication of mental disorders would lead to a greater number of persons attending education for boys than for girls.

Individuals with health conditions during late childhood and early adolescence form a major group at risk of upper-secondary educational dropout, even in Finland, where education is free-of-charge at all levels and the healthcare system is highly government-subsidized. Most of the health conditions that predicted dropout at age 17 years also predicted dropout at age 21 years, which implies that having a childhood health condition might not only delay the educational career but could also prevent young people from obtaining an upper-secondary diploma altogether.

The combined analysis of RRs and PAFs highlights the salience of perspective in preventive and supportive actions. Whereas some of the rarer conditions, such as epilepsy and psychosis, contribute little to explaining dropout as a population-level phenomenon, they significantly increase the risk of educational dropout among children facing them. When the emphasis is on reducing dropout at the population level, mood disorders (unipolar depression or anxiety), conduct disorders, and specific developmental disorders, such as learning difficulties, emerge as the key targets. ■

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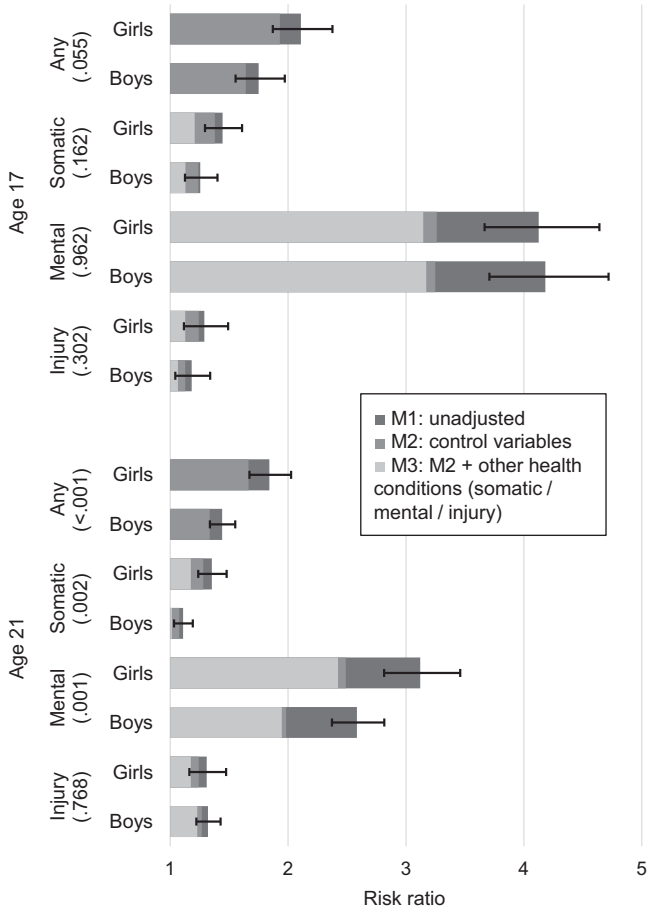

Figure 2. Crude and adjusted RRs of dropout from upper-secondary education at ages 17 and 21 years (n = 50 327 at both ages) according to the presence of health conditions at ages 10-16 years by sex and the type of health condition: 95% CIs for Model 1 (M1) and *P* values (in parentheses) for the sex difference in Model 2 (M2).

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Table I. Inpatient and outpatient primary diagnoses (ICD-10) included in the study

Health conditions	ICD-10 codes
Any condition	Somatic condition, mental disorder, or injury as defined below
Somatic condition	A00-E89, G00-N99, P00-Q99
Asthma	J45, J46
Allergy	H10.1, H10.45, J30.1-J30.9, K52.2, L20, L23, L27, T78, T80.5, T88.6
Dorsopathy	M40-M54
Migraine or severe headaches	G43, G44
Severe infection	A40-A41 (sepsis), G00-G03 (meningitis), J12-J18 (pneumonia)
Type 1 diabetes	E10
Visual or hearing impairment	H54, H90-H91
Epilepsy	G40, G41
Congenital heart disease	Q20-Q28
Rheumatoid arthritis	M08
Celiac disease	K90
Inflammatory bowel disease	K50, K51
Cancer	C00-C97
Cerebral palsy	G80
Other somatic condition	Other A00-E89, G00-N99, or P00-Q99
Mental disorder	F10-F69, F80-F99
Unipolar depression	F32-F33, excluding F32.3 and F33.3
Specific developmental disorder	F80-F83
Conduct disorder	F91, F92
Anxiety	F40-F42
ADHD	F90
Eating disorder	F50
Substance abuse disorder	F10-F19
Pervasive developmental disorder	F84
Psychosis	F20-F29, F30.2, F31.2, F31.5, F32.3, F33.3
Other mental disorder	Other F10-F69 or F80-F99
Injury	S00-S99, T00-T14
Fracture	S02, S12, S22, S32, S42, S52, S62, S72, S82, S92, T02
Intracranial injury	S06
Other injury	Other S00-S99, T00-T14

ADHD, attention deficit-hyperactivity disorder; *ICD-10*, *International Statistical Classification of Diseases and Related Health Problems, 10th edition.*

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Table II. The frequency distributions of participants and the prevalence (%) of dropout from upper-secondary education at ages 17 and 21 years by the control variables

Variables	Classification	%	Dropout, % age 17 y* n = 101 284	Age 21 y† n = 50 327
Birth year	Continuous	NA	NA	NA
Sex	Male	50.9	4.8	10.9
	Female	49.1	4.9	7.4
Birth quarter (derived from birth month)	First	25.3	4.6	9.7
	Second	26.0	4.8	9.0
	Third	25.6	4.7	9.3
	Fourth	23.2	5.3	8.7
Maternal age (biological mother's age at the child's birth), y	20 or younger	4.8	8.7	19.8
	21-25	22.5	5.6	11.6
	26-30	37.6	4.3	7.8
	31-35	24.5	4.2	7.0
	36-40	8.9	4.7	8.2
	41 or older	1.6	5.4	7.6
Immigrant status (second-generation contains persons with at least 1 parent not born in Finland)	Native-born	94.4	4.5	8.8
	Second generation	3.8	8.3	12.0
	First generation	1.8	16.0	20.8
Household income quintile (mean of annual taxable household incomes at ages 10-15 y, converted to 2014 Euros, divided by the number of OECD consumption units)	Highest	20.0	2.5	4.1
	Fourth	20.0	2.9	6.0
	Third	20.0	3.6	7.1
	Second	20.0	5.1	9.7
	Lowest	20.0	10.2	17.0
Highest level of parental education measured at ages 10-15 y; UNESCO ISCED classification recoded into 4 groups)	Higher tertiary	16.3	2.6	3.0
	Lower tertiary	37.1	2.9	5.9
	Secondary	40.2	5.9	11.9
	Basic	6.5	14.8	23.0
Family type (mode at ages 10-15 y)	Two parents	81.4	3.9	7.7
	Single parent	17.9	8.6	15.5
	Other	0.7	21.8	28.7
Persons per room, excluding kitchen (mean at ages 10-15 y classified into 3 categories + unknown)	1 or less	51.9	3.8	7.2
	1-2	43.5	5.8	10.9
	2 or more	4.3	7.5	13.4
	Unknown	0.3	13.5	35.7
Number of children <18 y living in the household (mode at ages 10-15 y)	1	13.4	5.4	9.6
	2	41.2	4.3	8.2
	3	28.4	4.4	8.8
	4	10.0	5.5	11.3
	5 or more	6.7	6.9	12.4
	Unknown	0.4	20.2	24.4
Region of residence (mode at ages 10-15 y based on the European Union NUTS 2 region, with the Capital region as a separate category)	Capital region	16.9	8.2	12.9
	Other Uusimaa	10.2	4.8	11.2
	Southern Finland	20.8	4.8	9.1
	Western Finland	25.7	3.9	8.1
	Northern/Eastern Finland	26.4	3.6	7.2
Type of municipality (mode at ages 10-15 y)	Urban	63.3	5.6	9.9
	Semi-urban	19.2	3.4	8.2
	Rural	17.5	3.5	7.6

ISCED, International Standard Classification of Education; *NUTS*, Nomenclature of territorial units for statistics; *OECD*, Organisation for Economic Co-operation and Development; *NA*, not available; *UNESCO*, United Nations Educational, Scientific and Cultural Organization.
*All contingency tables significant at $P < .001$ except for sex ($P = .585$) and birth quarter ($P = .001$).
†All contingency tables significant at $P < .001$ except for birth quarter ($P = .056$).

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Table VI. RRs* (adjusted for sex and control variables) of dropout from upper-secondary education at ages 17 and 21 years by the presence of health conditions (adjusted for other health conditions) and by the number of health conditions at ages 10-16 years

	Age 17 years (n = 101.284)		Age 21 years (n = 50.327)	
Health conditions	**RR**	**95% CI**	**RR**	**95% CI**
Independent associations†				
Asthma	1.01	(0.89-1.15)	0.99	(0.88-1.12)
Allergy	0.87	(0.75-1.02)	0.88	(0.75-1.03)
Dorsopathy	1.14	(0.96-1.35)	1.00	(0.82-1.22)
Migraine or severe headaches	**1.26**	(1.05-1.51)	1.12	(0.90-1.39)
Severe infection	**1.54**	(1.24-1.91)	**1.31**	(1.03-1.67)
Epilepsy	**2.08**	(1.73-2.51)	**1.41**	(1.13-1.77)
Type 1 diabetes	0.96	(0.71-1.29)	1.05	(0.79-1.41)
Visual or hearing impairment	**1.99**	(1.63-2.43)	1.04	(0.78-1.39)
Congenital heart disease	**2.12**	(1.68-2.69)	**1.42**	(1.03-1.96)
Rheumatoid arthritis	1.23	(0.85-1.76)	1.27	(0.87-1.83)
Celiac disease	1.12	(0.70-1.79)	1.02	(0.54-1.93)
Inflammatory bowel disease	1.12	(0.65-1.93)	0.82	(0.43-1.57)
Cancer	1.61	(1.05-2.46)	0.76	(0.37-1.56)
Cerebral palsy	**3.52**	(2.53-4.89)	**1.75**	(1.01-3.01)
Unipolar depression	**2.04**	(1.81-2.29)	**1.66**	(1.45-1.91)
Specific developmental disorder	**2.16**	(1.91-2.44)	**1.43**	(1.23-1.65)
Conduct disorder	**2.01**	(1.78-2.27)	**2.01**	(1.78-2.27)
Anxiety	**1.88**	(1.63-2.16)	**1.78**	(1.48-2.14)
ADHD	**1.38**	(1.14-1.67)	1.26	(0.99-1.61)
Eating disorder	0.97	(0.70-1.34)	1.10	(0.74-1.64)
Substance abuse disorder	**1.73**	(1.41-2.12)	**1.79**	(1.48-2.17)
Pervasive developmental disorder	**2.23**	(1.77-2.82)	**1.46**	(1.09-1.95)
Psychosis	**1.99**	(1.58-2.49)	**1.47**	(1.11-1.96)
Fracture	1.04	(0.95-1.14)	**1.11**	(1.02-1.20)
Intracranial injury	1.15	(0.95-1.39)	**1.21**	(1.00-1.46)
Number of health conditions (ref = 0)‡				
1	**1.52**	(1.43-1.62)	**1.22**	(1.15-1.30)
2	**2.59**	(2.38-2.83)	**1.82**	(1.66-2.00)
3	**3.62**	(3.18-4.13)	**2.26**	(1.91-2.67)
4 or more	**4.69**	(3.85-5.71)	**2.48**	(1.88-3.25)

*RRs in bold are statistically significant at the 0.05 level.
†All health conditions simultaneously included in the model.
‡The number of health conditions listed above.

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