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Intersectional inequalities in paediatric infectious diseases: a national cohort study in Sweden

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ABSTRACT

Background It is well known that socially deprived children are more likely to be hospitalised for infections. Less is known about how different social disadvantages interact. Therefore, we examine intersectional inequalities in overall, upper respiratory, lower respiratory, enteric and genitourinary infections in the first 5 years of life.

Methods We conducted a population-based retrospective cohort study of Swedish children born between 1998 and 2015. Inequalities were examined using analysis of individual heterogeneity and discriminatory accuracy as the analytical framework. A variable with 60 intersectional strata was created by combining information on maternal education, household income, sex/gender and maternal migration status. We estimated the incidence rates of infectious disease hospitalisation for each intersectional strata and the associations between intersectional strata and infectious disease hospitalisations using logistic regression models. We furthermore quantified the discriminatory ability of the intersectional strata with respect to infectious disease hospitalisation.

Results The study included 1785 588 children and 318 080 hospital admissions. The highest overall incidence of hospitalisations for infections was found in boys born to low-educated mothers who lived in families with the lowest household income. The overall incidence of infections was unrelated to household income in children born to highly educated mothers. The ability of the intersectional strata to discriminate between children with and without infections was poor.

Conclusion We found that inequalities in paediatric infectious diseases were shaped by the intersections of different social disadvantages. These inequalities should be addressed by public health policies that reach all children.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ There are large inequalities in paediatric infectious diseases related to socioeconomic circumstances, ethnicity and sex/gender.
⇒ Less is known about how different social disadvantages interact.

WHAT THIS STUDY ADDS

⇒ We found complex inequalities in paediatric infectious diseases.
⇒ The overall incidence of paediatric infectious diseases was unrelated to household income in children born to highly educated mothers, and the incidence of enteric infections was higher in boys born to low-educated migrant mothers.
⇒ However, information on sociodemographic variables explained only a small proportion of the individual risk of infection.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Our findings support broad public health policies reaching all children over interventions targeting children in high-risk groups.

INTRODUCTION

There are inequalities in paediatric infectious diseases related to socioeconomic circumstances, immigration and sex/gender. Deprived socioeconomic circumstances are associated with an increased risk of paediatric infections including gastroenteritis and respiratory infection.[1 2] Socioeconomic circumstances can influence child health through material, psychosocial, behavioural and structural pathways.[3] Boys are generally more susceptible to infections than girls, and these differences may be due to both biological and social factors.[4] Children of immigrants have an increased risk of certain paediatric infectious diseases.[5] However, the relationship between migration and child health is complex and influenced by various factors including health-related policies in the receiving country.[6] Moreover, children facing multiple social disadvantages are more likely to acquire certain diseases including HIV/AIDS, hepatitis A and cytomegalovirus infections.[7 8] While numerous studies have examined sociodemographic inequalities in paediatric infectious diseases, less is known about the interplay between different social disadvantages.

The concept of *intersectionality* offers a theoretical framework for analysis of multiple social disadvantages.[9] Intersectional theory is a critical theory that focuses on how inequalities are generated and upheld by interlocking systems of privilege and oppression.[10] The term *intersectionality* was first used to describe how black women's lives are formed by racism and sexism in ways that separate analyses of race and gender cannot capture.[11] Since then, intersectionality has influenced various academic disciplines including epidemiology. In traditional epidemiological analysis, inequalities are examined using one social category or the sum of several social categories.[9] In contrast, an intersectional approach assumes that individuals' health is shaped by the interaction of multiple social categories of equal importance.[9] These categories are not necessarily additive, as one category may come with

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privilege and health in one context but with oppression and ill-health in another.[9]

To our knowledge, only a few national studies have examined sociodemographic inequalities in overall paediatric infectious disease hospitalisations; none of these studies has applied an intersectional framework. Therefore, the aim of this study was to examine intersectional inequalities in hospitalisations for infectious diseases related to maternal education, household income, sex/gender, maternal migration status and their combinations, in the first 5 years of life.

METHODS

We did a population-level, retrospective cohort study including children born in Sweden between 1998 and 2015. Intersectional inequalities in paediatric infectious diseases were examined using analysis of individual heterogeneity and discriminatory accuracy (AIHDA) as the analytical framework.[12 13] While traditional methods focus on differences between group averages, AIHDA considers both differences between group averages and the individual heterogeneity around those averages.[14] In AIHDA, each group is considered to represent a specific context.[14] Analysis includes (1) Visualisation of groups' differences using plots and (2) Quantifying the size of these differences, that is, estimating the share of the total individual variance that is at the group level.[14] AIHDA can be applied using traditional fixed-effect regression models or more sophisticated random-effect regression models (multilevel AIHDA).[14] In our study, we used a fixed-effect approach.

Data source

We used national health and administrative registers; the Medical Birth Register was linked with the National Inpatient Register, the Cause of Death Register, the Longitudinal Integration Database for health insurance and labour market studies and the Total Population Register. The National Medical Birth Register contains information on prenatal and perinatal care for 98%–99% of all deliveries in Sweden.[15] The National Inpatient Register holds information on more than 99% of all hospital discharges; validation studies have shown that registered diagnoses are correct in about 85%–95% of the cases.[16] The Cause of Death Register contains mortality data with almost complete coverage since 1952.[17] The Longitudinal Integration Database for health insurance and labour market studies holds information on various socioeconomic variables including income and education.[18] The Total Population Register holds information on migration. Registers were linked by the Centre for Epidemiology at the Swedish National Board of Health and Welfare using the national registration number, a unique personal identification number assigned to all Swedish residents at birth or immigration. All data were pseudo-anonymised before analysis.

Exposures

We obtained information on maternal education and disposable household income from the Longitudinal Integration Database for health, insurance and labour market studies. Maternal education was categorised as secondary school or less (≤9 years), upper secondary school (10–12 years) and postsecondary education (≥13 years). Disposable household income at birth was divided into annual quintiles (Q1–Q5), with the fifth quintile (Q5) representing the highest household income. Data on sex, year of birth and maternal country of birth were obtained from the Medical Birth Register. Sex/gender was categorised as girl or boy. Maternal migration status was categorised as non-immigrant (Swedish-born) and immigrant (other). An intersectional variable with 60 strata was created by combining the five categories of household income, the three categories of maternal education, the two categories of sex and the two categories of maternal migration status.

Outcomes

Information on childhood hospitalisations with a principal diagnosis of infectious disease was retrieved from the National Inpatient Register. We adapted a previously developed coding scheme to identify infection-related International Classification of Diseases, Tenth Revision (ICD-10) codes. This coding scheme has previously been reviewed by a panel of infectious disease clinicians, microbiologists and disease coding experts.[19] The main outcome was overall infectious disease hospitalisations. Secondary outcomes were upper respiratory, lower respiratory, enteric and genitourinary infections (online supplemental table 1).

Statistical analysis

We examined intersectional inequalities using AIHDA as the analytical framework.[12 13] Analyses were performed in three steps for each infectious disease category: overall, upper respiratory, lower respiratory, enteric and genitourinary infections. In the first step, we calculated incidence rates (IR) with 95% CIs for each intersectional stratum, that is, for each combination of household income, maternal education, sex/gender and maternal migration status. In the second step, we fitted three consecutive logistic regression models. The first logistic model included year of birth. The second logistic model included sociodemographic variables: household income, maternal education, sex/gender, maternal migration status and year of birth; this model estimated the joint effect of socioeconomic indicators excluding interaction effects. The third logistic model included the intersectional strata variable and year of birth; this model estimated the joint effect of socioeconomic indicators allowing multiplicative interaction effects. In all models, the outcome variable was binary, indicating hospitalisation or not. Results were presented as ORs with 95% CIs. In the third step, we quantified the ability of the logistic models to discriminate between individuals with and without the outcome. This discriminatory accuracy (DA) quantifies how much of the total individual variance in an outcome is explained by the predictor variable(s).[14] The DA of each logistic model was calculated as the area under the receiver operating characteristics curve (AUC); 95% CIs were calculated using the DeLong method.[20] Values of AUC can range from 0.5 (indicating no predictive accuracy) to 1 (perfect discrimination). The DA was classified as absent or very small (AUC=0.5–0.6), moderate (AUC>0.6–≤0.7), large (AUC>0.7–≤0.8) and very large (AUC>0.8).[13] We calculated the incremental change in the AUC value (ΔAUC) between models. The ΔAUC quantifies the change in the DA obtained by a model in comparison with a previous model. The intersectional variable in the third model allows multiplicative interactions between sociodemographic variables. If a multiplicative interaction is present, the ΔAUC in the third model will be positive.[12]

In sensitivity analysis, we examined the effect of maternal migration status in more detail by categorising maternal migration status as non-immigrant (Swedish-born), other high-income countries, upper-middle-income countries, lower-middle-income countries and low-income countries using the World Bank Atlas method.[21] An intersectional variable with 150 strata was created by combining the five categories of household income, the three

Table 1 Sociodemographic characteristics of the study population

	Included	Excluded*
	n=1785 588	n=42 842
	% (n)	% (n)
Maternal education in years		
≥13	46.5 (829 620)	0.0 (4)
10–12	42.0 (750 600)	0.0 (2)
≤9	11.5 (205 368)	0.0 ()
Household income		
Q5	20.3 (363 277)	4.2 (1789)
Q4	20.4 (363 736)	3.1 (1332)
Q3	20.3 (362 828)	5.2 (2245)
Q2	20.0 (357 121)	18.6 (7953)
Q1	19.0 (338 626)	61.8 (26 455)
Sex/gender		
Female/girl	48.5 (866 886)	48.8 (20 928)
Male/boy	51.5 (918 702)	51.1 (21 907)
Maternal migration status		
Non-immigrant	80.1 (1430 706)	10.9 (4682)
Immigrant	19.9 (354 882)	89.1 (38 160)
Year of birth		
Mean (SD)	2007.0 (5.1)	2006.8 (5.2)

Values are percentages (numbers) unless stated otherwise.
*Children with missing data were excluded. Data on variables were available in 0%–100% of the excluded children.

categories of maternal education, the two categories of sex and the five categories of maternal migration status. All statistical analyses were performed using Stata Statistical Software (Release V.17. College Station, Texas, USA).

RESULTS

Study population

The Medical Birth Register included 1828 430 children born in Sweden between 1998 and 2015. We excluded 42 842 children with missing data, leaving 1785 588 children. A majority of excluded children were born to immigrant mothers and lived in families with low household incomes (table 1). Children were followed until 5 years of age, end of the follow-up period (31 December 2016), censuring due to emigration (n=21 370) or death (n=3494). The study included 7974 833 person years of follow-up time and 318 080 hospital admissions: 66 743 upper respiratory, 82 309 lower respiratory, 68 032 enteric, 20 825 genitourinary and 80 171 other hospital admissions. Online supplemental table 2 presents the most frequent ICD codes in each infectious disease category.

Table 2 presents adjusted associations between socioeconomic demographic factors and hospitalisations for infectious diseases. Maternal education was inversely associated with all paediatric infections. For example, in comparison with children born to highly educated (≥13 years) mothers, the odds of being hospitalised for overall infections were 1.35 (OR 1.35; 95% CI 1.33 to 1.37) higher in children born to mothers with low (≤9 years) education. Household income was associated with overall, upper respiratory, enteric and, to a lesser extent, genitourinary

Table 2 Associations between socioeconomic demographic factors and hospitalisation for overall, upper respiratory, lower respiratory, enteric and genitourinary infections

	Overall infections	Upper respiratory infections	Lower respiratory infections	Enteric infections	Genitourinary infections
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Maternal education					
≥13	1 ref	1 ref	1 ref	1 ref	1 ref
10–12	1.13 (1.12 to 1.14)	1.19 (1.17 to 1.21)	1.12 (1.10 to 1.14)	1.13 (1.11 to 1.15)	1.10 (1.07 to 1.14)
≤9	1.35 (1.33 to 1.37)	1.43 (1.40 to 1.47)	1.40 (1.37 to 1.44)	1.35 (1.31 to 1.38)	1.13 (1.08 to 1.19)
Household income					
Q5	1 ref	1 ref	1 ref	1 ref	1 ref
Q4	1.06 (1.04 to 1.07)	1.15 (1.12 to 1.18)	0.99 (0.97 to 1.02)	1.06 (1.03 to 1.09)	1.09 (1.04 to 1.15)
Q3	1.08 (1.06 to 1.09)	1.19 (1.16 to 1.22)	0.97 (0.95 to 1.00)	1.08 (1.05 to 1.11)	1.07 (1.02 to 1.12)
Q2	1.09 (1.07 to 1.11)	1.20 (1.17 to 1.24)	0.97 (0.95 to 0.98)	1.14 (1.11 to 1.16)	1.06 (1.01 to 1.11)
Q1	1.10 (1.08 to 1.12)	1.19 (1.16 to 1.23)	0.95 (0.92 to 0.97)	1.21 (1.18 to 1.25)	1.05 (1.00 to 1.10)
Sex/gender					
Female/girl	1 ref	1 ref	1 ref	1 ref	1 ref
Male/boy	1.22 (1.21 to 1.23)	1.41 (1.39 to 1.43)	1.34 (1.32 to 1.36)	1.07 (1.05 to 1.08)	0.77 (0.75 to 0.79)
Maternal migration status					
Non-immigrant	1 ref	1 ref	1 ref	1 ref	1 ref
Immigrant	0.97 (0.96 to 0.98)	0.94 (0.92 to 0.96)	0.91 (0.89 to 0.92)	1.06 (1.04 to 1.08)	1.11 (1.06 to 1.15)
Year of birth					
Per year	0.98 (0.97 to 0.98)	0.96 (0.96 to 0.96)	0.99 (0.99 to 1.00)	0.96 (0.96 to 0.97)	0.98 (0.98 to 0.98)
AUC	0.56 (0.56 to 0.56)	0.59 (0.59 to 0.60)	0.55 (0.55 to 0.55)	0.57 (0.57 to 0.57)	0.56 (0.55 to 0.56)
ΔAUC*	0.02	0.03	0.04	0.01	0.03

Analyses excluded children with missing data (n=42 842), leaving 1785 588 children. The analyses included 249 644 overall infectious hospitalisations, 59 928 upper respiratory hospitalisations, 73 465 lower respiratory hospitalisations, 62 985 enteric hospitalisations and 18 750 genitourinary hospitalisations. Models included household income, maternal education, sex/gender, maternal migration status and year of birth.
*AUC model with maternal education, household income, maternal immigration, sex and year of birth compared with AUC with year of birth (online supplemental table 3).
AUC, area under the receiver operating characteristic curve; ΔAUC, incremental change in the AUC value.

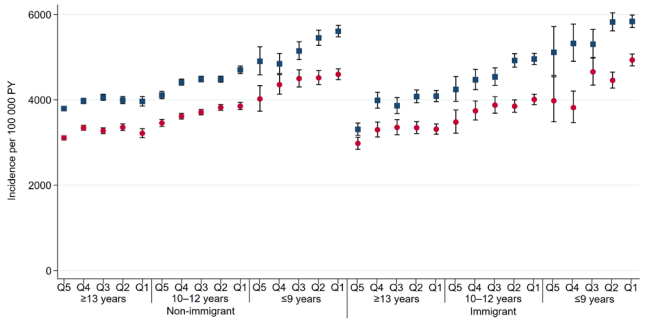

Figure 1 Incidence rates of overall infectious disease hospitalisations. Boys (blue squares), girls (red circles) household income (Q5–Q1), maternal education (≥13 years, 10–12 years and ≤9 years) and maternal migration status (non-immigrant and immigrant). Vertical lines represent 95% CI.

infections. The odds of overall and respiratory infections were higher in boys. In comparison with children born to non-immigrant mothers, the odds of genitourinary infection were slightly higher (OR 1.11; 95% CI 1.06 to 1.15), and the odds of lower respiratory infection were slightly lower (OR 0.91; 95% CI 0.89 to 0.92) in children born to immigrant mothers.

Intersectional analysis

Figure 1 shows IRs of overall infections in each intersectional strata; figure 2 shows IRs of upper respiratory, lower respiratory, enteric and genitourinary infections. Table 3 presents the odds of hospitalisation for infectious diseases in each intersectional strata, with girls born to highly educated non-migrant mothers (≥13 years) living in families with high household income (Q5) as the reference category. The overall incidence of infectious disease hospitalisations decreased with the duration of maternal education for children born to both migrant and non-migrant mothers (figure 1). For children born to mothers with low (≤9 years) or middle (10–12 years) education, the incidence of overall infections also decreased with higher household income. The same pattern was observed in regression analyses (table 3). Interestingly, the incidence of overall infections was not related to household income in children born to mothers with high (≥13 years) education. This indicates that the overall incidence of infectious disease was shaped by the intersection of education and income.

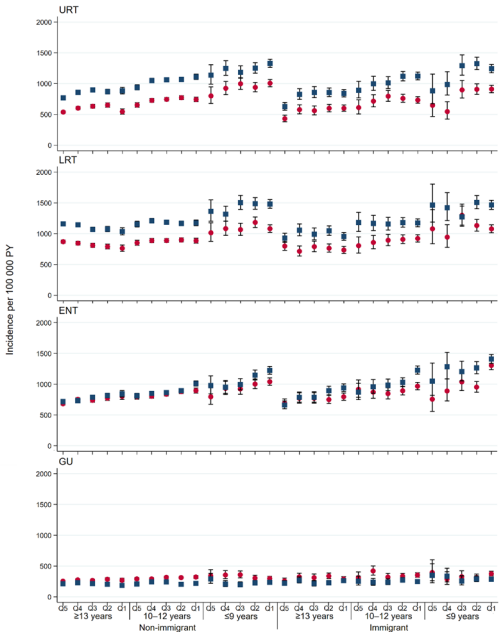

Figure 2 Incidence rates of hospitalisations for upper respiratory (URT), lower respiratory (LRT), enteric (ENT) and genitourinary (GU) infections. Boys (blue squares), girls (red circles), household income (Q5–Q1), maternal education (≥13 years, 10–12 years and ≤9 years) and maternal migration status (non-immigrant and immigrant). Vertical lines represent 95% CI.

The effect of sex/gender varied between infectious disease categories. The incidence of respiratory infections was higher in boys compared with girls, the incidence of enteric infections was higher in boys born to low-educated migrant mothers, and the incidence of genitourinary infections was slightly lower in boys compared with girls (figure 2). The same pattern was observed in regression analyses, except that the odds of genitourinary infection were lower in boys (table 3). A higher frequency of repeated admissions in boys may explain the difference between IRs and results from logistic regression models.

The ability of sociodemographic variables to discriminate between children with and without infections was poor. In table 2, the DA ranged from AUC 0.55 (95% CI 0.55 to 0.55) in the model for lower respiratory infections to AUC 0.59 (95% CI 0.59 to 0.60) in the model for upper respiratory infections. The ΔAUC between models with intersectional strata variables and models with sociodemographic variables were all <0.01, indicating that allowing multiplicative interactions did not increase the proportion of the total individual variance explained by the sociodemographic variables.

Sensitivity analysis

In sensitivity analysis, we used an intersectional strata variable with maternal migration status categorised as non-immigrant (Swedish-born), other high-income countries, upper-middle-income countries, lower-middle-income countries and low-income countries. Compared with children born to Swedish mothers, the odds of overall infections and respiratory infections were both decreased in children born to mothers from other high-income countries. The more detailed information on maternal migration status did not improve the DA. The ΔAUC between models with two categories of maternal migration status and models with five categories of maternal migration status, were all <0.01 (online supplemental table 4).

DISCUSSION

In this nationwide cohort, we found complex inequalities in paediatric infectious diseases related to maternal education, household income, sex/gender, maternal migration status and their combinations. The overall incidence of paediatric infections was associated with disadvantaged socioeconomic circumstances, the incidence of respiratory infections was higher in boys, and the incidence of genitourinary infections was higher in girls. Interestingly, the overall incidence of paediatric infections was unrelated to household income in children born to highly educated mothers. Additionally, an increased incidence of enteric infections was only found in boys born to low-educated migrant mothers. Consequently, inequalities in our study were shaped by the intersections of different social disadvantages.

In our study, we found large inequalities in paediatric infectious diseases related to socioeconomic circumstances. This

Table 3 Associations between intersectional strata and hospitalisation for infectious diseases, overall and categories of infectious diseases

	Overall infections	Upper respiratory infections	Lower respiratory infections	Enteric infections	Genitourinary infections
Strata	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Non-immigrant, female/girl, ≥13, Q5	1 ref	ref 1	1 ref	1 ref	1 ref
Non-immigrant, female/girl, ≥13, Q4	1.07 (1.04 to 1.10)	1.15 (1.08 to 1.22)	0.96 (0.91 to 1.01)	1.10 (1.04 to 1.16)	1.08 (0.99 to 1.17)
Non-immigrant, female/girl, ≥13, Q3	1.06 (1.03 to 1.09)	1.22 (1.14 to 1.30)	0.93 (0.88 to 0.98)	1.09 (1.03 to 1.15)	1.03 (0.93 to 1.13)
Non-immigrant, female/girl, ≥13, Q2	1.08 (1.05 to 1.12)	1.25 (1.17 to 1.34)	0.91 (0.86 to 0.97)	1.12 (1.05 to 1.19)	1.15 (1.03 to 1.27)
Non-immigrant, female/girl, ≥13, Q1	1.02 (0.98 to 1.07)	1.03 (0.94 to 1.13)	0.85 (0.79 to 0.92)	1.14 (1.06 to 1.24)	1.05 (0.92 to 1.20)
Non-immigrant, female/girl, 10–12, Q5	1.13 (1.09 to 1.17)	1.20 (1.12 to 1.29)	0.99 (0.93 to 1.06)	1.15 (1.08 to 1.23)	1.10 (0.99 to 1.23)
Non-immigrant, female/girl, 10–12, Q4	1.16 (1.12 to 1.19)	1.34 (1.26 to 1.42)	1.04 (0.99 to 1.10)	1.16 (1.10 to 1.23)	1.14 (1.04 to 1.25)
Non-immigrant, female/girl, 10–12, Q3	1.19 (1.15 to 1.22)	1.38 (1.30 to 1.46)	1.04 (0.99 to 1.09)	1.19 (1.13 to 1.25)	1.22 (1.12 to 1.33)
Non-immigrant, female/girl, 10–12, Q2	1.22 (1.19 to 1.26)	1.42 (1.34 to 1.51)	1.05 (1.00 to 1.11)	1.25 (1.19 to 1.32)	1.21 (1.11 to 1.32)
Non-immigrant, female/girl, 10–12, Q1	1.23 (1.19 to 1.27)	1.38 (1.29 to 1.47)	1.02 (0.97 to 1.09)	1.29 (1.21 to 1.37)	1.26 (1.14 to 1.39)
Non-immigrant, female/girl, ≤9, Q5	1.23 (1.12 to 1.35)	1.45 (1.21 to 1.74)	1.14 (0.97 to 1.35)	1.11 (0.92 to 1.33)	1.33 (1.01 to 1.76)
Non-immigrant, female/girl, ≤9, Q4	1.41 (1.32 to 1.51)	1.63 (1.43 to 1.85)	1.26 (1.11 to 1.42)	1.36 (1.20 to 1.54)	1.35 (1.10 to 1.66)
Non-immigrant, female/girl, ≤9, Q3	1.42 (1.34 to 1.50)	1.85 (1.66 to 2.06)	1.28 (1.15 to 1.42)	1.31 (1.17 to 1.46)	1.41 (1.18 to 1.68)
Non-immigrant, female/girl, ≤9, Q2	1.49 (1.41 to 1.56)	1.76 (1.60 to 1.93)	1.39 (1.27 to 1.51)	1.45 (1.33 to 1.59)	1.20 (1.03 to 1.42)
Non-immigrant, female/girl, ≤9, Q1	1.49 (1.43 to 1.54)	1.84 (1.71 to 1.98)	1.27 (1.19 to 1.36)	1.50 (1.40 to 1.61)	1.12 (0.99 to 1.28)
Non-immigrant, male/boy, ≥13, Q5	1.24 (1.21 to 1.27)	1.45 (1.37 to 1.52)	1.33 (1.28 to 1.39)	1.04 (0.99 to 1.09)	0.82 (0.75 to 0.89)
Non-immigrant, male/boy, ≥13, Q4	1.29 (1.25 to 1.32)	1.64 (1.56 to 1.73)	1.31 (1.25 to 1.37)	1.07 (1.02 to 1.13)	0.90 (0.82 to 0.98)
Non-immigrant, male/boy, ≥13, Q3	1.33 (1.29 to 1.37)	1.71 (1.61 to 1.81)	1.24 (1.18 to 1.30)	1.15 (1.09 to 1.21)	0.85 (0.77 to 0.94)
Non-immigrant, male/boy, ≥13, Q2	1.32 (1.28 to 1.36)	1.65 (1.55 to 1.76)	1.24 (1.17 to 1.31)	1.19 (1.12 to 1.27)	0.82 (0.74 to 0.92)
Non-immigrant, male/boy, ≥13, Q1	1.25 (1.20 to 1.30)	1.60 (1.48 to 1.73)	1.17 (1.09 to 1.25)	1.21 (1.12 to 1.30)	0.73 (0.63 to 0.85)
Non-immigrant, male/boy, 10–12, Q5	1.35 (1.30 to 1.39)	1.68 (1.58 to 1.79)	1.36 (1.29 to 1.44)	1.17 (1.10 to 1.25)	0.82 (0.73 to 0.92)
Non-immigrant, male/boy, 10–12, Q4	1.44 (1.40 to 1.48)	1.94 (1.83 to 2.04)	1.43 (1.37 to 1.50)	1.21 (1.15 to 1.28)	0.97 (0.89 to 1.07)
Non-immigrant, male/boy, 10–12, Q3	1.48 (1.44 to 1.52)	1.95 (1.85 to 2.06)	1.41 (1.34 to 1.47)	1.24 (1.17 to 1.30)	0.96 (0.88 to 1.05)
Non-immigrant, male/boy, 10–12, Q2	1.46 (1.42 to 1.50)	1.95 (1.85 to 2.06)	1.37 (1.31 to 1.44)	1.30 (1.23 to 1.37)	0.81 (0.73 to 0.89)
Non-immigrant, male/boy, 10–12, Q1	1.50 (1.45 to 1.55)	1.98 (1.86 to 2.10)	1.36 (1.29 to 1.43)	1.40 (1.32 to 1.48)	0.87 (0.78 to 0.97)
Non-immigrant, male/boy, ≤9, Q5	1.54 (1.41 to 1.67)	1.97 (1.68 to 2.30)	1.58 (1.37 to 1.83)	1.34 (1.14 to 1.58)	1.12 (0.83 to 1.50)
Non-immigrant, male/boy, ≤9, Q4	1.61 (1.52 to 1.72)	2.30 (2.06 to 2.57)	1.61 (1.45 to 1.78)	1.32 (1.17 to 1.49)	0.78 (0.60 to 1.01)
Non-immigrant, male/boy, ≤9, Q3	1.65 (1.56 to 1.74)	2.11 (1.91 to 2.34)	1.80 (1.65 to 1.96)	1.39 (1.25 to 1.54)	0.82 (0.66 to 1.03)
Non-immigrant, male/boy, ≤9, Q2	1.81 (1.73 to 1.90)	2.33 (2.14 to 2.54)	1.75 (1.62 to 1.89)	1.66 (1.53 to 1.81)	0.91 (0.76 to 1.09)
Non-immigrant, male/boy, ≤9, Q1	1.80 (1.73 to 1.86)	2.40 (2.24 to 2.57)	1.71 (1.61 to 1.82)	1.73 (1.62 to 1.85)	0.90 (0.79 to 1.04)
Immigrant, female/girl, ≥13, Q5	0.88 (0.83 to 0.93)	0.75 (0.66 to 0.87)	0.85 (0.77 to 0.95)	0.93 (0.83 to 1.04)	0.99 (0.83 to 1.18)
Immigrant, female/girl, ≥13, Q4	1.01 (0.95 to 1.08)	1.06 (0.92 to 1.22)	0.75 (0.66 to 0.85)	1.08 (0.96 to 1.22)	1.23 (1.02 to 1.49)
Immigrant, female/girl, ≥13, Q3	1.01 (0.94 to 1.08)	1.04 (0.90 to 1.20)	0.82 (0.73 to 0.93)	1.11 (0.99 to 1.26)	1.11 (0.91 to 1.35)
Immigrant, female/girl, ≥13, Q2	1.02 (0.97 to 1.07)	1.10 (0.98 to 1.23)	0.80 (0.72 to 0.88)	1.05 (0.95 to 1.16)	1.27 (1.09 to 1.47)
Immigrant, female/girl, ≥13, Q1	1.00 (0.96 to 1.05)	1.08 (0.98 to 1.19)	0.79 (0.72 to 0.86)	1.12 (1.03 to 1.22)	1.12 (0.97 to 1.29)
Immigrant, female/girl, 10–12, Q5	1.05 (0.95 to 1.16)	1.02 (0.82 to 1.26)	0.90 (0.75 to 1.07)	1.24 (1.05 to 1.47)	1.21 (0.91 to 1.61)
Immigrant, female/girl, 10–12, Q4	1.18 (1.09 to 1.27)	1.29 (1.11 to 1.50)	1.00 (0.88 to 1.15)	1.28 (1.12 to 1.47)	1.66 (1.37 to 2.03)
Immigrant, female/girl, 10–12, Q3	1.24 (1.16 to 1.32)	1.48 (1.30 to 1.67)	1.02 (0.91 to 1.14)	1.22 (1.09 to 1.38)	1.21 (0.99 to 1.47)
Immigrant, female/girl, 10–12, Q2	1.18 (1.12 to 1.24)	1.39 (1.26 to 1.54)	0.99 (0.91 to 1.09)	1.26 (1.15 to 1.38)	1.38 (1.20 to 1.60)
Immigrant, female/girl, 10–12, Q1	1.24 (1.19 to 1.30)	1.33 (1.22 to 1.45)	1.01 (0.94 to 1.09)	1.38 (1.28 to 1.49)	1.40 (1.24 to 1.58)
Immigrant, female/girl, ≤9, Q5	1.11 (0.94 to 1.32)	0.97 (0.67 to 1.42)	1.29 (0.99 to 1.69)	0.95 (0.68 to 1.33)	1.28 (0.79 to 2.08)
Immigrant, female/girl, ≤9, Q4	1.23 (1.10 to 1.38)	1.05 (0.80 to 1.36)	1.11 (0.90 to 1.37)	1.31 (1.06 to 1.61)	1.07 (0.73 to 1.56)
Immigrant, female/girl, ≤9, Q3	1.44 (1.31 to 1.57)	1.66 (1.40 to 1.98)	1.43 (1.23 to 1.65)	1.48 (1.26 to 1.74)	1.27 (0.96 to 1.68)
Immigrant, female/girl, ≤9, Q2	1.34 (1.27 to 1.42)	1.62 (1.45 to 1.80)	1.17 (1.06 to 1.30)	1.35 (1.22 to 1.49)	1.23 (1.03 to 1.47)
Immigrant, female/girl, ≤9, Q1	1.48 (1.42 to 1.54)	1.65 (1.52 to 1.79)	1.15 (1.07 to 1.24)	1.80 (1.68 to 1.93)	1.39 (1.23 to 1.58)
Immigrant, male/boy, ≥13, Q5	1.00 (0.95 to 1.06)	1.13 (1.01 to 1.27)	1.01 (0.92 to 1.11)	0.91 (0.82 to 1.02)	0.77 (0.64 to 0.93)
Immigrant, male/boy, ≥13, Q4	1.20 (1.13 to 1.27)	1.48 (1.32 to 1.67)	1.14 (1.03 to 1.26)	1.13 (1.00 to 1.27)	0.96 (0.79 to 1.18)
Immigrant, male/boy, ≥13, Q3	1.19 (1.12 to 1.26)	1.55 (1.38 to 1.75)	1.05 (0.95 to 1.17)	1.14 (1.01 to 1.28)	0.82 (0.65 to 1.02)
Immigrant, male/boy, ≥13, Q2	1.27 (1.21 to 1.33)	1.58 (1.44 to 1.74)	1.09 (1.00 to 1.19)	1.27 (1.16 to 1.39)	0.86 (0.72 to 1.02)
Immigrant, male/boy, ≥13, Q1	1.26 (1.21 to 1.32)	1.56 (1.44 to 1.70)	1.02 (0.94 to 1.10)	1.29 (1.19 to 1.39)	0.96 (0.83 to 1.11)
Immigrant, male/boy, 10–12, Q5	1.34 (1.23 to 1.46)	1.54 (1.30 to 1.82)	1.39 (1.21 to 1.61)	1.22 (1.03 to 1.43)	0.88 (0.64 to 1.20)
Immigrant, male/boy, 10–12, Q4	1.40 (1.31 to 1.51)	1.87 (1.65 to 2.13)	1.31 (1.16 to 1.47)	1.29 (1.13 to 1.47)	0.99 (0.77 to 1.26)
Immigrant, male/boy, 10–12, Q3	1.45 (1.37 to 1.54)	1.85 (1.65 to 2.06)	1.35 (1.22 to 1.50)	1.38 (1.24 to 1.54)	0.96 (0.78 to 1.19)
Immigrant, male/boy, 10–12, Q2	1.55 (1.48 to 1.62)	2.07 (1.90 to 2.25)	1.32 (1.22 to 1.43)	1.47 (1.35 to 1.60)	1.06 (0.90 to 1.24)

Continued

Table 3 Continued

Strata	Overall infections OR (95% CI)	Upper respiratory infections OR (95% CI)	Lower respiratory infections OR (95% CI)	Enteric infections OR (95% CI)	Genitourinary infections OR (95% CI)
Immigrant, male/boy, 10–12, Q1	1.52 (1.46 to 1.58)	2.04 (1.89 to 2.19)	1.27 (1.19 to 1.36)	1.70 (1.59 to 1.82)	0.93 (0.81 to 1.07)
Immigrant, male/boy, ≤9, Q5	1.41 (1.21 to 1.64)	1.35 (0.98 to 1.84)	1.52 (1.20 to 1.94)	1.46 (1.12 to 1.90)	1.27 (0.80 to 2.03)
Immigrant, male/boy, ≤9, Q4	1.65 (1.48 to 1.83)	1.70 (1.38 to 2.11)	1.61 (1.35 to 1.92)	1.75 (1.46 to 2.11)	1.33 (0.95 to 1.88)
Immigrant, male/boy, ≤9, Q3	1.72 (1.59 to 1.86)	2.45 (2.12 to 2.82)	1.42 (1.23 to 1.64)	1.71 (1.48 to 1.98)	1.06 (0.79 to 1.43)
Immigrant, male/boy, ≤9, Q2	1.77 (1.68 to 1.86)	2.30 (2.09 to 2.53)	1.66 (1.52 to 1.80)	1.78 (1.63 to 1.95)	1.13 (0.94 to 1.35)
Immigrant, male/boy, ≤9, Q1	1.80 (1.74 to 1.87)	2.24 (2.09 to 2.41)	1.58 (1.49 to 1.69)	1.98 (1.85 to 2.11)	1.01 (0.88 to 1.16)
Year of birth					
Per year	0.98 (0.97 to 0.98)	0.96 (0.96 to 0.96)	0.99 (0.99 to 1.00)	0.96 (0.96 to 0.97)	0.98 (0.97 to 0.98)
AUC	0.56 (0.56 to 0.56)	0.59 (0.59 to 0.59)	0.55 (0.55 to 0.55)	0.57 (0.57 to 0.57)	0.56 (0.55 to 0.56)
ΔAUC*	<0.01	<0.01	<0.01	<0.01	<0.01

Analyses excluded children with missing data (n=42 842), leaving 1785 588 children. The analyses included 249 644 overall infectious hospitalisations, 59 928 upper respiratory hospitalisations, 73 465 lower respiratory hospitalisations, 62 985 enteric hospitalisations, 18 750 genitourinary hospitalisations and 71 673 other infectious disease hospitalisations.
*AUC model with intersectional strata variable and year of birth compared with AUC model with sociodemographic variables and year of birth (table 2).
AUC, area under the receiver operating characteristic curve; ΔAUC, incremental change in the AUC value.

was anticipated from previous research, as socioeconomically deprived children are known to be more susceptible to common infections such as gastroenteritis and respiratory infection.[1 2] Moreover, a few previous large cohort studies have found socioeconomic inequalities in overall paediatric infections.[1 19] Our intersectional analyses showed that the overall incidence of paediatric infectious diseases was unrelated to family income in children born to highly educated mothers. This suggests that education can buffer against the detrimental consequences of poverty. The observed inequalities can be reduced by broad policies targeting the unequal distribution of power, resources and opportunities.[3] They may also be reduced by specific policies targeting pathways linking socioeconomic circumstances to paediatric infections, for example, unequal exposure to pregnancy smoking, excess weight during pregnancy and breast feeding.[22]

We found that boys were more likely to be hospitalised for respiratory infections and that boys born to low-educated mothers were more likely to be hospitalised for enteric infections. Similar to our results, an Israeli twin study found that the risk of infection-related hospitalisations was higher in boys compared with girls.[23] Differences between boys and girls may be due to biological *sex* and social *gender*. The immune system is influenced by sex hormones, where testosterone has an overall suppressive effect, while oestrogen promotes humoral and cellular immune responses.[4] Girls and boys may also be treated differently by their parents and health providers. Therefore, a higher risk of paediatric infections in boys may be due to biological vulnerability and/or because they receive different care.

In our study, the overall incidence of paediatric infectious diseases was similar for children of immigrant mothers and non-immigrant mothers. Our results are overall consistent with a Norwegian study reporting a slightly increased risk of overall infections and a decreased risk of lower respiratory tract infections in children of immigrants.[5] In Sweden and Norway, children in asylum-seeking families have similar entitlements to healthcare as national children.[24] This may explain the weak association between parental migration status and overall infections. However, the Norwegian study reported an increased risk of specific infections, for example, tuberculosis.[5]

The ability of sociodemographic variables to discriminate between children with and without infections was poor indicating that a small proportion of the individual risk of infection was due to the social context.[14] Consequently, our results support broad public health policies reaching all children over interventions targeting children in high-risk groups.

Strengths and limitations

To our knowledge, this is the first large national cohort study to examine intersectional inequalities in overall paediatric infectious diseases; previous studies have focused on specific paediatric infections, particularly HIV/AIDS.[7 25 26] We used a large national cohort with almost complete data on parental education and income, child sex/gender, maternal migration status and infectious disease hospitalisations. This allowed us to examine intersectional inequalities overall, as well as for major categories of infectious diseases. Nevertheless, our study has several limitations. First, we used pseudo-anonymised register data, which means that infections could not be confirmed by clinical, laboratory or radiological findings obtained from medical records. Second, information on education in the longitudinal integration database for health insurance and labour market studies is often missing for immigrants educated outside Sweden.[18] Consequently, children of these parents were excluded, which may explain why the odds of infection were similar in children born to Swedish mothers and children born to mothers from low/middle-income countries. Third, we analysed intersectional inequalities using a fixed-effect AIHDA approach. An alternative is a multilevel AIHDA approach. Whereas the multilevel effect approach is more aligned with intersectional theory as it explicitly models the context as a second level, the fixed-effect AIHDA approach is more accessible.[14] Finally, our study does not examine several important dimensions of health inequalities including ethnicity and geography. Unfortunately, information on ethnicity is not available in Swedish registers; adding information on the 21 regions in Sweden would increase the number of strata substantially and require another analytical strategy, for example, a multilevel AIHDA approach.

CONCLUSION

In our study, we found complex inequalities in paediatric infectious diseases related to maternal education, family income, sex/gender, maternal migration status and their combinations.

Intersectional analyses showed that the overall incidence of paediatric infectious diseases was shaped by the interaction of low maternal education and low household income and that the incidence of enteric infections was shaped by the interaction of low maternal education, male sex/gender and maternal migration status. Consequently, our intersectional approach revealed patterns of inequalities that traditional epidemiological analysis would have missed. Additionally, we found that information on sociodemographic variables explained only a small proportion of the individual risk of infection. Consequently, the observed inequalities should be addressed by public health policies reaching all children.

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Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by the Regional Ethics Board in Umeå (reference numbers 2012-265-31M and 2017-399-32M) and by the Swedish Ethical Review Authority (reference number 2021-06337-02).The study uses pseudo-anonymised register data.

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Data availability statement Data may be obtained from a third party and are not publicly available. We used pseudo-anonymised register data obtained from third parties. It includes sensitive information and some access restrictions may apply. Interested researchers need to obtain data directly from the National Board of Health and Welfare in Sweden (socialstyrelsen@socialstyrelsen.se) and from Statistics Sweden (scb@scb.se).

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