Socioeconomic disparities associated with 29 common infectious diseases in Sweden, 2005–14: an individually matched case-control study

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Summary

Background Although the association between low socioeconomic status and non-communicable diseases is well established, the effect of socioeconomic factors on many infectious diseases is less clear, particularly in high-income countries. We examined the associations between socioeconomic characteristics and 29 infections in Sweden.

Methods We did an individually matched case-control study in Sweden. We defined a case as a person aged 18–65 years who was notified with one of 29 infections between 2005 and 2014, in Sweden. Cases were individually matched with respect to sex, age, and county of residence with five randomly selected controls. We extracted the data on the 29 infectious diseases from the electronic national register of notified infections and infectious diseases (SmiNet). We extracted information on country of birth, educational and employment status, and income of cases and controls from Statistics Sweden's population registers. We calculated adjusted matched odds ratios (amOR) using conditional logistic regression to examine the association between infections or groups of infections and place of birth, education, employment, and income.

Findings We included 173 729 cases notified between Jan 1, 2005, and Dec 31, 2014 and 868 645 controls. Patients with invasive bacterial diseases, blood-borne infectious diseases, tuberculosis, and antibiotic-resistant infections were more likely to be unemployed (amOR 1·59, 95% CI 1·49–1·70; amOR 3·62, 3·48–3·76; amOR 1·88, 1·65–2·14; and amOR 1·73, 1·67–1·79, respectively), to have a lower educational attainment (amOR 1·24, 1·15–1·34; amOR 3·63, 3·45–3·81; amOR 2·14, 1·85–2·47; and amOR 1·07, 1·03–1·12, respectively), and to have a lowest income (amOR 1·52, 1·39–1·66; amOR 3·64, 3·41–3·89; amOR 3·17, 2·49–4·04; and amOR 1·2, 1·14–1·25, respectively). By contrast, patients with food-borne and water-borne infections were less likely than controls to be unemployed (amOR 0·74, 95% CI 0·72–0·76), to have lower education (amOR 0·75, 0·73–0·77), and lowest income (amOR 0·59, 0·58–0·61).

Interpretation These findings indicate persistent socioeconomic inequalities in infectious diseases in an egalitarian high-income country with universal health care. We recommend using these findings to identify priority interventions and as a baseline to monitor programmes addressing socioeconomic inequalities in health.

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Introduction

In the past few decades, overall population health indicators have improved across Europe, but not all population groups have benefited equally, implying that widespread health inequalities still exist between and within countries.[1] Education, occupation, and income account for most health inequalities within countries.[2] Several studies have reported higher rates of non-communicable diseases in disadvantaged groups than in populations with higher socioeconomic status.[3]

Even though associations between socioeconomic conditions and infectious diseases have been reported in low-income and high-income countries, most studies have focused on a small number of diseases and infections, such as tuberculosis and HIV infection. Therefore, a scientific basis for public health priorities and effective strategies for interventions to achieve a more equal access to health care are scarce for many other infectious diseases.

Sweden is not only one of the wealthiest countries in the world but also one of the most egalitarian in terms of distribution of resources.[4] The health-care system is universal and mainly tax funded. Responsibility for providing health care lies with Sweden's 21 independent counties.[5] Regularly updated population registers are available and are extensively used for medical research.[6,7] A civic registration number (personal number), acting as a unique identifier, is assigned to all Swedish individuals at birth and to long-term residents, which makes linking registers possible.[6,7]

The Swedish surveillance system is based on the statutory reporting of 65 infectious diseases and syndromes according to updated official case definitions.[8] Both clinicians and laboratories report communicable infections using full patient identifiers in most instances, including

Research in context

Evidence before this study

We searched PubMed for articles published between Jan 1, 1990, and Jan 1, 2018, using a different combination of several meSH terms including "socioeconomic factors", "poverty", "employment", "educational status", "income", "communicable diseases", "infections", "developed countries", "Europe", "Scandinavian and Nordic countries", and "Sweden". We also used specific terms for each disease included in the study. The search was done in English but no language restrictions were applied. We screened the reference list of the articles we considered relevant for the study objectives to identify other important papers. Additionally, we consulted the websites of national and international organisations such as WHO, the Organisation for Economic Co-operation and Development, Eurostat, Statistics Sweden, and the European Centre for Disease Prevention and Control. Articles were considered relevant if they assessed the relation between socioeconomic factors and the occurrence of infectious diseases.

For several of the infectious diseases that we investigated we found only a few studies that assessed this relation. Most of these studies reported inverse associations between socioeconomic factors and occurrence of most infectious diseases with the exception of water-borne and food-borne diseases, for which the relation was sometimes negative, but more often positive. Several studies assessed the relation between socioeconomic factors and occurrence of infectious diseases on an ecological level. In several other studies, this relation was studied by means of deprivation scores of the residence neighbourhood, or through spatial analysis. Most of the studies focused on risk groups or disadvantaged areas. Only very few studies, done on a national level, used socioeconomic indicators measured on an individual level.

Added value of this study

In our analysis we included around 170 000 cases notified with 29 infectious diseases and around 850 000 controls over a period of 10 years. For both cases and controls we used individual data to assess the relation between socioeconomic factors and occurrence of infectious diseases. To our knowledge, this is the only recent study that has assessed this relation using individual data in a high-income country, on a national scale. In the study, patients with invasive bacterial diseases, hepatitis B virus infection or hepatitis C virus infection, and antibiotic-resistant infections were more likely to be unemployed, to have a lower educational attainment, and a lower income. By contrast, patients with food-borne and water-borne infections were less likely to be unemployed, to have lower educational attainment, or lower income.

Implications of all the available evidence

The results of our study show persistent socioeconomic inequalities in infectious diseases in an egalitarian high-income country with a universal health-care system. Since the association between socioeconomic factors and the occurrence of the most frequent infectious diseases was assessed following the same approach, these data can be used to identify priority interventions and monitor programmes aimed to address socioeconomic inequalities in health. Additionally, our study suggests that education, employment, and household income can influence health outcomes possibly along different pathways, and thereby provide different opportunities for prevention.

the personal number, to the local public health authorities and the Public Health Agency of Sweden over the internet. The personal number is used to automatically link clinical and laboratory notifications on the same patient and disease episode.[9]

We examined whether the occurrence of 29 common infectious diseases is associated with individual socioeconomic factors in a comparatively wealthy and egalitarian country such as Sweden.

Methods

Study design and participants

This study was designed as an individually matched case-control study in Sweden. We included cases of infections notified between 2005 and 2014 (study period). A control group was randomly selected using computer-generated random numbers from updated population registers from the year of notification, which were provided by the government agency Statistics Sweden (Stockholm, Sweden).[7] We individually matched each person with an infectious disease to five controls with respect to sex, age (ten age groups: 18–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, and 60–65 years), and county of residence. Before random selection of controls, we excluded from the population registers individuals who were younger than 18 years and older than 65 years, individuals with the same infection or disease as the matched case, and records with missing values in any of the matching or explanatory variables.

We defined a case as a person aged 18–65 years who was notified to have at least one of the 29 infections included in the study between 2005 and 2014. We excluded people who were reported to have an infection or infectious disease without a personal number. We included only one report for people who had different episodes of the same disease notified more than once in the same year. We included only the first notification for hepatitis A virus (HAV), hepatitis B virus (HBV), hepatitis C virus (HCV), and tularaemia in the same person notified more than once during the entire study period.

Statistics Sweden replaced person number with a unique number identifier in the dataset of the cases (anonymised dataset). In the population datasets, the person number was also replaced by a unique identifier to match different datasets with the dataset of the cases in an anonymised fashion.

The key to convert the personal number into the unique identifier was preserved for 3 months, as per Statistics Sweden internal regulations, to reduce the risk of breaking the privacy of individuals. The study received approval from the Regional Ethical Review Board of Stockholm (protocol 2015/1979-31).

Data extraction

We extracted from the electronic national register of notified infections and infectious diseases (SmiNet)[9] all records of reports from 2005 until 2014, except for HIV, genital chlamydia infections, syphilis, and gonorrhoea infections, because these reports are anonymous. We then selected infections and diseases with more than 500 reports during the study period and infections and diseases that had been notifiable for more than 5 years before applying case-based exclusion criteria.

Overall, we included 29 infections and diseases. We included four invasive bacterial diseases (invasive pneumococcal disease, invasive meningococcal disease, invasive *Haemophilus influenzae* disease, and invasive group A β-haemolytic streptococcal [iGAS] infection); ten food-borne and water-borne infections, including HAV infection, campylobacteriosis, cryptosporidiosis, enterohaemorrhagic *Escherichia coli* (EHEC) infection, listeriosis, giardiasis, amoebiasis, salmonellosis, shigellosis, and yersiniosis; two blood-borne infections, consisting of HBV and HCV infections; and four antibiotic-resistant infections, including extended spectrum β-lactamase-producing Enterobacteriaceae (ESBL) infection, meticillin-resistant *Staphylococcus aureus* (MRSA) infection, vancomycin-resistant enterococci (VRE) infection, and *Streptococcus pneumoniae* with reduced sensitivity to penicillin (PNSP) infection. Additionally, we included tuberculosis, atypical mycobacteriosis, pertussis, legionellosis, viral meningoencephalitis, malaria, dengue, nephropathia epidemica caused by Puumala virus infection, and tularaemia.

For each case, we extracted from SmiNet the personal number, notified infection or disease, the year of notification, and for food-borne and water-borne infections, whether the disease was domestically acquired or travel related. For the individuals acting as controls, we obtained from Statistics Sweden individual-level data on demographic and annually updated socioeconomic conditions for each year of the study period.

Explanatory and outcome variables

We included as explanatory variables place of birth, highest academic attainment, employment status, and county quintile of the household-equivalised disposable income. Place of birth was classified as either being born in Sweden with both parents born in Sweden, being born in Sweden with at least one parent born abroad, or being born abroad. Highest academic attainment was classified as primary or lower secondary education (overall 9 years of study or less), higher secondary education (>9–12 years of study), and post-secondary or tertiary education (>12 years of study).

For the employment status, we used Statistic Sweden's employment categories estimated based on a model built on income data and surveys on labour (Labour Force Survey) to mimic the International Labour Organization employment definition.[10] For the analysis, we considered as employed all individuals who declared an income for any given year and as unemployed all individuals who did not declare any income for that given year.

Statistics Sweden provided information on individual disposable income estimated as the sum of all taxable and tax-free income minus tax and other negative transfers. We estimated household disposable income as the sum of the disposable income of all individuals of the same household. Negative values were considered as zero. For each year, we estimated the equivalised disposable income by dividing the household disposable income by the total number of equivalent adults using the Swedish equivalence scale (1 for the first adult, 0·51 for the second adult, 0·6 for any additional adult, 0·52 for the first child aged 0–19 years, and 0·42 for each additional child aged 0–19 years). In instances in which no adults were in the household, we used an adapted scale. Observations were first divided on the basis of county of residence, then ordered according to the

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Individuals in population registers	9 047 748	9 113 250	9 182 919	9 256 333	9 340 656	9 415 526	9 482 791	9 555 934	9 644 837	9 747 342
Exclusion criteria										
No birth date available	1581	1778	1445	970	513	6	4	4	4	4
Aged <18 years or >65 years	3 409 868	3 421 523	3 434 493	3 455 218	3 478 706	3 532 381	3 578 991	3 633 171	3 702 731	3 780 405
Missing at least one variable	84 636	102 132	99 481	106 132	115 207	118 519	111 145	113 403	118 091	118 888
Sample frame*	5 551 663	5 597 817	5 647 500	5 694 013	5 735 230	5 764 620	5 792 646	5 809 256	5 824 011	5 848 045

*From the reported sample frame, we also excluded notified cases when we selected the controls for the corresponding conditions.

Table 1: **Sample frame for the random selection of controls, by year of notification**

equivalised disposable income from highest to lowest income, and finally grouped into corresponding quintiles in each county of residence. Matching and explanatory variables were measured the same year as notification to account for changes in explanatory variables over time, both at the society and individual level.

We considered as outcomes each individually notified infection or disease. We also grouped some outcomes into four categories: blood-borne diseases, invasive bacterial diseases, antibiotic-resistant infections, and food-borne and water-borne infections.

Statistical analysis

We calculated unadjusted and adjusted matched odds ratios with 95% CIs and did a linear trend analysis on the income quintiles using conditional logistic regression. In

	Total	Sex		Age (years)					Place of birth and parents' place of birth		
		Male	Female	18–29	30–39	40–49	50–59	60–65	Born in Sweden and parents born in Sweden	Born in Sweden and at least one parent born abroad	Born abroad
Hepatitis A virus infection	367	182 (50%)	185 (50%)	130 (35%)	69 (19%)	82 (22%)	58 (16%)	28 (8%)	216 (59%)	63 (17%)	88 (24%)
Campylobacteriosis	57 674	30 367 (53%)	27 307 (47%)	16 106 (28%)	11 422 (20%)	12 531 (22%)	11 442 (20%)	6173 (11%)	46 360 80%)	6807 (12%)	4507 (8%)
Cryptosporidiosis	1585	665 (42%)	920 (58%)	435 (27%)	484 (31%)	370 (23%)	210 (13%)	86 (5%)	1304 (82%)	216 (14%)	65 (4%)
EHEC infection	1737	717 (41%)	1020 (59%)	510 (29%)	415 (24%)	326 (19%)	306 (18%)	180 (10%)	1306 (75%)	179 (10%)	252 (15%)
Listeriosis	126	56 (44%)	70 (56%)	11 (9%)	25 (20%)	8 (6%)	35 (28%)	47 (37%)	82 (65%)	11 (9%)	33 (26%)
Giardiasis	5464	2703 (49%)	2761 (51%)	1552 (28%)	1383 (25%)	1116 (20%)	893 (16%)	520 (10%)	3930 (72%)	576 (11%)	958 (18%)
Amoebiasis	991	544 (55%)	447 (45%)	258 (26%)	276 (28%)	244 (25%)	149 (15%)	64 (6%)	541 (55%)	77 (8%)	373 (38%)
Salmonellosis	22 641	11 103 (49%)	11 538 (51%)	6158 (27%)	3939 (17%)	4639 (20%)	5120 (23%)	2785 (12%)	18 266 (81%)	2228 (10%)	2147 (9%)
Shigellosis	3301	1324 (40%)	1977 (60%)	872 (26%)	712 (22%)	674 (20%)	655 (20%)	388 (12%)	2432 (74%)	378 (11%)	491 (15%)
Yersiniosis	2069	1094 (53%)	975 (47%)	662 (32%)	448 (22%)	388 (19%)	363 (18%)	208 (10%)	1579 (76%)	239 (12%)	251 (12%)
Invasive pneumococcal disease	5369	2796 (52%)	2573 (48%)	279 (5%)	701 (13%)	923 (17%)	1574 (29%)	1892 (35%)	4331 (81%)	421 (8%)	617 (11%)
Invasive meningococcal disease	261	140 (54%)	121 (46%)	109 (42%)	23 (9%)	35 (13%)	48 (18%)	46 (18%)	202 (77%)	26 (10%)	33 (13%)
Invasive *Haemophilus influenzae* disease	520	203 (39%)	317 (61%)	42 (8%)	68 (13%)	92 (18%)	134 (26%)	184 (35%)	414 (80%)	49 (9%)	57 (11%)
iGAS infection	1787	854 (48%)	933 (52%)	178 (10%)	370 (21%)	418 (23%)	415 (23%)	406 (23%)	1372 (77%)	194 (11%)	221 (12%)
Hepatitis B virus infection	7145	4068 (57%)	3077 (43%)	2213 (31%)	2396 (34%)	1429 (20%)	804 (11%)	303 (4%)	1183 (17%)	342 (5%)	5620 (79%)
Hepatitis C virus infection	15 911	10 261 (64%)	5650 (36%)	5248 (33%)	3164 (20%)	3143 (20%)	3311 (21%)	1045 (7%)	10 441 (66%)	2384 (15%)	3086 (19%)
ESBL infection	19 176	5713 (30%)	13 463 (70%)	4349 (23%)	3377 (18%)	3432 (18%)	4241 (22%)	3777 (20%)	10 985 (57%)	1718 (9%)	6563 (34%)
MRSA infection	7673	3510 (46%)	4163 (54%)	2233 (29%)	2054 (27%)	1577 (21%)	1098 (14%)	711 (9%)	3692 (48%)	741 (10%)	3240 (42%)
PNSP infection	1014	448 (44%)	566 (56%)	136 (13%)	289 (29%)	216 (21%)	200 (20%)	173 (17%)	661 (65%)	106 (10%)	247 (24%)
VRE infections	584	349 (60%)	235 (40%)	54 (9%)	57 (10%)	94 (16%)	167 (29%)	212 (36%)	390 (67%)	59 (10%)	135 (23%)
Dengue	959	488 (51%)	471 (49%)	326 (34%)	200 (21%)	193 (20%)	173 (18%)	67 (7%)	721 (75%)	119 (12%)	119 (12%)
Malaria	644	444 (69%)	200 (31%)	182 (28%)	182 (28%)	151 (23%)	97 (15%)	32 (5%)	198 (31%)	45 (7%)	401 (62%)
Nephropathia epidemica	3569	2086 (58%)	1483 (42%)	373 (10%)	552 (15%)	856 (24%)	1060 (30%)	728 (20%)	3179 (89%)	218 (6%)	172 (5%)
Tularaemia	2035	1213 (60%)	822 (40%)	188 (9%)	311 (15%)	529 (26%)	592 (29%)	415 (20%)	1756 (86%)	163 (8%)	116 (6%)
Atypical mycobacteriosis	1234	522 (42%)	712 (58%)	179 (15%)	152 (12%)	193 (16%)	326 (26%)	384 (31%)	827 (67%)	75 (6%)	332 (27%)
Legionellosis	625	415 (66%)	210 (34%)	25 (4%)	37 (6%)	103 (16%)	227 (36%)	233 (37%)	498 (80%)	52 (8%)	75 (12%)
Tuberculosis	3064	1588 (52%)	1476 (48%)	1031 (34%)	943 (31%)	566 (18%)	355 (12%)	169 (6%)	282 (9%)	79 (3%)	2703 (88%)
Viral meningoencephalitis	4589	2220 (48%)	2369 (52%)	1152 (25%)	1500 (33%)	938 (20%)	619 (13%)	380 (8%)	3526 (77%)	565 (12%)	498 (11%)
Pertussis	1615	717 (44%)	898 (56%)	491 (30%)	387 (24%)	369 (23%)	221 (14%)	147 (9%)	1163 (72%)	200 (12%)	252 (16%)

Data are presented as number or number (%). EHEC=enterohaemorrhagic *Escherichia coli*. iGAS=invasive group Aβ-haemolytic streptococci. ESBL=extended spectrum β-lactamase-producing Enterobacteriaceae. MRSA=meticillin-resistant *Staphylococcus aureus*. PNSP=*Streptococcus pneumoniae* with reduced sensitivity to penicillin. VRE=vancomycin-resistant enterococci.

Table 2: **Age, sex, and place of birth and parents' place of birth of cases by infectious disease, Sweden, 2005–14**

the multivariable models, we included all explanatory variables. For each model, we estimated the variance inflation factor (VIF) to check for multicollinearity. For food-borne and water-borne diseases, we first included all notified cases and then stratified according to whether the infection was acquired in Sweden or abroad according to the notification. We used Stata 13 software for the analysis.

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

	Total	Education			Employment		Income quintile				
		Post-secondary	Higher secondary	Lower secondary or less	Employed	Unemployed	First (highest)	Second	Third	Fourth	Fifth (lowest)
Hepatitis A virus infection	367	153 (42%)	150 (41%)	64 (17%)	300 (82%)	67 (18%)	85 (23%)	60 (16%)	61 (17%)	58 (16%)	103 (28%)
Campylobacteriosis	57 674	23 343 (40%)	28 087 (49%)	6244 (11%)	52 993 (92%)	4681 (8%)	19 356 (34%)	14 374 (25%)	10 661 (18%)	7202 (12%)	6081 (11%)
Cryptosporidiosis	1585	777 (49%)	685 (43%)	123 (7.8%)	1478 (93%)	107 (7%)	456 (29%)	379 (24%)	321 (20%)	247 (16%)	182 (11%)
EHEC infection	1737	630 (36%)	843 (49%)	264 (15%)	1553 (89%)	184 (11%)	438 (25%)	390 (22%)	384 (22%)	290 (17%)	235 (14%)
Listeriosis	126	42 (33%)	42 (33%)	42 (33%)	71 (56%)	55 (44%)	27 (21%)	31 (24%)	15 (12%)	23 (18%)	30 (24%)
Giardiasis	5464	2866 (52%)	2008 (37%)	590 (11%)	4759 (87%)	705 (13%)	1609 (29%)	1142 (21%)	818 (15%)	743 (14%)	1152 (21%)
Amoebiasis	991	488 (49%)	321 (32%)	182 (18%)	738 (74%)	253 (26%)	212 (21%)	144 (15%)	137 (14%)	131 (13%)	367 (37%)
Salmonellosis	22 641	7399 (33%)	12 095 (53%)	3147 (14%)	20 853 (92%)	1788 (8%)	7442 (33%)	5788 (26%)	4275 (18%)	2845 (13%)	2291 (10%)
Shigellosis	3301	1738 (53%)	1271 (38%)	292 (9%)	2998 (91%)	303 (9%)	1163 (35%)	698 (21%)	548 (17%)	402 (12%)	490 (15%)
Yersiniosis	2069	850 (41%)	999 (48%)	220 (11%)	1918 (93%)	151 (7%)	634 (31%)	472 (23%)	450 (22%)	286 (14%)	227 (11%)
Invasive pneumococcal disease	5369	1391 (26%)	2645 (49%)	1333 (25%)	3836 (71%)	1533 (29%)	1369 (25%)	1091 (20%)	998 (19%)	950 (18%)	961 (18%)
Invasive meningococcal disease	261	70 (27%)	135 (52%)	56 (21%)	206 (79%)	55 (21%)	64 (25%)	59 (23%)	47 (18%)	38 (15%)	53 (20%)
Invasive *Haemophilus influenzae* disease	520	142 (27%)	257 (49%)	121 (23%)	372 (72%)	148 (28%)	119 (23%)	120 (23%)	118 (23%)	80 (15%)	83 (16%)
iGAS infection	1787	647 (36%)	803 (45%)	337 (19%)	1346 (75%)	441 (25%)	410 (23%)	348 (19%)	336 (19%)	322 (18%)	371 (21%)
Hepatitis B virus infection	7145	2055 (29%)	2415 (34%)	2675 (37%)	3639 (51%)	3506 (49%)	463 (7%)	571 (8%)	808 (11%)	1126 (16%)	4177 (58%)
Hepatitis C virus infection	15 911	1855 (12%)	6959 (44%)	7097 (45%)	6413 (40%)	9498 (60%)	1066 (7%)	1455 (9%)	1739 (11%)	2858 (18%)	8793 (55%)
ESBL infection	19 176	7059 (37%)	8162 (43%)	3955 (21%)	13 318 (69%)	5858 (31%)	4299 (22%)	3290 (17%)	2961 (15%)	3285 (17%)	5341 (28%)
MRSA infection	7673	2875 (37%)	3258 (42%)	1540 (20%)	5280 (69%)	2393 (31%)	1170 (15%)	1168 (15%)	1199 (16%)	1372 (18%)	2764 (36%)
PNSP infection	1014	421 (42%)	417 (41%)	176 (17%)	770 (76%)	244 (24%)	223 (22%)	209 (21%)	199 (20%)	183 (18%)	200 (20%)
VRE infections	584	136 (23%)	276 (47%)	172 (29%)	304 (52%)	280 (48%)	112 (19%)	88 (15%)	91 (16%)	125 (21%)	168 (29%)
Dengue	959	441 (46%)	456 (48%)	62 (6%)	887 (92%)	72 (8%)	345 (36%)	208 (22%)	176 (18%)	99 (10%)	131 (14%)
Malaria	644	275 (43%)	252 (39%)	117 (18%)	489 (76%)	155 (24%)	81 (13%)	81 (13%)	92 (14%)	109 (17%)	281 (44%)
Nephropathia epidemica	3569	994 (28%)	2016 (56%)	559 (16%)	3147 (88%)	422 (12%)	1082 (30%)	829 (23%)	653 (18%)	559 (16%)	446 (12%)
Tularaemia	2035	690 (34%)	1072 (53%)	273 (13%)	1858 (91%)	177 (9%)	621 (31%)	515 (25%)	411 (20%)	289 (14%)	199 (10%)
Atypical mycobacteriosis	1234	412 (33%)	524 (42%)	298 (24%)	820 (66%)	414 (34%)	306 (25%)	273 (22%)	205 (17%)	193 (16%)	257 (21%)
Legionellosis	625	167 (27%)	316 (51%)	142 (23%)	497 (80%)	128 (20%)	236 (38%)	150 (24%)	92 (15%)	79 (13%)	68 (11%)
Tuberculosis	3064	778 (25%)	952 (31%)	1334 (44%)	1475 (48%)	1589 (52%)	129 (4%)	181 (6%)	285 (9%)	516 (17%)	1953 (64%)
Viral meningoencephalitis	4589	1884 (41%)	2116 (46%)	589 (13%)	4122 (90%)	467 (10%)	1009 (22%)	1026 (22%)	1042 (23%)	843 (18%)	669 (15%)
Pertussis	1615	661 (41%)	730 (45%)	224 (14%)	1404 (87%)	211 (13%)	394 (24%)	351 (22%)	340 (21%)	282 (17%)	248 (15%)

Data are presented as number or number (%). EHEC=enterohaemorrhagic *Escherichia coli*. iGAS=invasive group A β-haemolytic streptococci. ESBL=extended spectrum β-lactamase Enterobacteriaceae. MRSA=methicillin-resistant *Staphylococcus aureus*. PNSP=*Streptococcus pneumoniae* with reduced sensitivity to penicillin. VRE=vancomycin-resistant enterococci.

Table 3: **Education, employment status, and income among cases of the 29 infectious diseases, Sweden, 2005–14**

	Cases	Controls	Unadjusted comparison		Adjusted comparison	
			mOR (95% CI)	p value	amOR (95% CI)	p value
Blood-borne infections (hepatitis B virus infection and hepatitis C virus infection)						
Place of birth and parents' place of birth						
Born in Sweden and parents born in Sweden	11 624 (50%)	82 944 (72%)	1 (ref)	..	1 (ref)	..
Born in Sweden and at least one parent born abroad	2726 (12%)	12 389 (11%)	1·62 (1·55–1·70)	<0·0001	1·28 (1·21–1·35)	<0·0001
Born abroad	8706 (38%)	19 947 (17%)	3·28 (3·18–3·39)	<0·0001	1·9 (1·82–1·97)	<0·0001
Education						
Post-secondary school	3910 (17%)	41 588 (36%)	1 (ref)	..	1 (ref)	..
Higher secondary school	9374 (41%)	56 727 (49%)	1·85 (1·78–1·93)	<0·0001	1·71 (1·63–1·78)	<0·0001
Lower secondary school or less	9772 (42%)	16 995 (15%)	6·73 (6·45–7·03)	<0·0001	3·63 (3·45–3·81)	<0·0001
Employment status						
Employed	10 052 (44%)	99 352 (86%)	1 (ref)	..	1 (ref)	..
Unemployed	13 004 (56%)	15 928 (14%)	8·34 (8·07–8·63)	<0·0001	3·62 (3·48–3·76)	<0·0001
Income*						
First quintile (highest)	1529 (7%)	25 953 (23%)	1 (ref)	..	1 (ref)	..
Second quintile	2026 (9%)	25 926 (22%)	1·45 (1·35–1·55)	<0·0001	1·19 (1·10–1·27)	<0·0001
Third quintile	2547 (11%)	22 732 (20%)	2·19 (2·04–2·34)	<0·0001	1·55 (1·44–1·66)	<0·0001
Fourth quintile	3984 (17%)	18 718 (16%)	4·23 (3·97–4·51)	<0·0001	2·24 (2·09–2·39)	<0·0001
Fifth quintile (lowest)	12 970 (56%)	21 951 (19%)	12 (11–13)	<0·0001	3·64 (3·41–3·89)	<0·0001
Invasive infectious diseases (invasive pneumococcal disease, invasive meningococcal disease, invasive *Haemophilus influenzae* disease, and iGAS infection						
Place of birth and parents' place of birth						
Born in Sweden and parents born in Sweden	6319 (80%)	30 234 (76%)	1 (ref)	..	1 (ref)	..
Born in Sweden and at least one parent born abroad	690 (9%)	3189 (8%)	1·03 (0·94–1·12)	0·56	0·97 (0·89–1·06)	0·49
Born abroad	928 (12%)	6262 (16%)	0·7 (0·65–0·76)	<0·0001	0·56 (0·52–0·61)	<0·0001
Education						
Post-secondary school	2250 (28%)	13 507 (34%)	1 (ref)	..	1 (ref)	..
Higher secondary school	3840 (48%)	18 589 (47%)	1·25 (1·18–1·33)	<0·0001	1·13 (1·06–1·20)	<0·0001
Lower secondary school or less	1847 (23%)	7589 (19%)	1·5 (1·40–1·61)	<0·0001	1·24 (1·15–1·34)	<0·0001
Employment status						
Employed	5760 (73%)	32 538 (82%)	1 (ref)	..	1 (ref)	..
Unemployed	2177 (27%)	7102 (18%)	1·78 (1·68–1·88)	<0·0001	1·59 (1·49–1·70)	<0·0001
Income†						
First quintile (highest)	1962 (25%)	12 713 (32%)	1 (ref)	..	1 (ref)	..
Second quintile	1618 (20%)	9170 (23%)	1·17 (1·09–1·26)	<0·0001	1·12 (1·04–1·20)	<0·0001
Third quintile	1499 (19%)	7029 (17%)	1·43 (1·33–1·55)	<0·0001	1·34 (1·24–1·45)	<0·0001
Fourth quintile	1390 (17%)	5286 (13%)	1·77 (1·64–1·92)	<0·0001	1·56 (1·44–1·69)	<0·0001
Fifth quintile (lowest)	1468 (18%)	5487 (13%)	1·82 (1·68–1·96)	<0·0001	1·52 ()1·39–1·66)	<0·0001
Antibiotic-resistant infections (ESBL, MRSA, VRE, and PNSP)						
Place of birth and parents' place of birth						
Born in Sweden and parents born in Sweden	15 638 (55%)	100 989 (71%)	1 (ref)	..	1 (ref)	..
Born in Sweden and at least one parent born abroad	2624 (9%)	14 799 (10%)	1·18 (1·12–1·23)	<0·0001	1·12 (1·07–1·17)	<0·0001
Born abroad	10 185 (36%)	26 447 (19%)	2·59 (2·51–2·67)	<0·0001	2·05 (1·98–2·12)	<0·0001
Education						
Post-secondary school	10 491 (37%)	55 765 (39%)	1 (ref)	..	1 (ref)	..
Higher secondary school	12 113 (43%)	64 967 (46%)	1 (0·97–1·03)	0·92	0·98 (0·95–1·01)	0·21
Lower secondary school or less	5843 (21%)	21 503 (15%)	1·48 (1·43–1·54)	<0·0001	1·07 (1·03–1·12)	0·0004

(Table 4 continues on next page)

Results

From the register of notifiable infections and infectious diseases, we extracted 298 663 notified cases reported between Jan 1, 2005, and Dec 31, 2014. Of the 124 934 cases that were excluded, 17 203 (14%) were not included because they had no social security number, 97 316 (78%) because they were either younger than 18 years or older than 65 years, 619 (<1%) were not in population registers, 1791 (1%) were duplicates, and 8005 (6%) were missing at least one variable. Overall, we included 173 729 cases and 868 645 controls (appendix). Table 1 shows the sample frame for the selection of controls. Demographic and socioeconomic characteristics of cases included in the study are reported in table 2 and table 3.

When we examined the relationship between groups of infectious diseases and socioeconomic characteristics, we found that lower education, unemployment, and lower income were associated with higher notifications of blood-borne infectious diseases, invasive bacterial diseases, tuberculosis, and antibiotic-resistant infections (table 4). When we examined these associations in individual infectious diseases, the results suggested that unemployment and low income were associated with HBV infection, HCV infection, invasive pneumococcal disease, VRE infection, and ESBL infection (table 5). An association

See Online for appendix

	Cases	Controls	Unadjusted comparison		Adjusted comparison	
			mOR (95% CI)	p value	amOR (95% CI)	p value
(Continued from previous page)						
Employment status						
Employed	19 672 (69%)	119 556 (84%)	1 (ref)	..	1 (ref)	..
Unemployed	8775 (31%)	22 679 (16%)	2·42 (2·35–2·50)	<0·0001	1·73 (1·67–1·79)	<0·0001
Income‡						
First quintile (highest)	5804 (20%)	35 267 (25%)	1 (ref)	..	1 (ref)	..
Second quintile	4755 (17%)	31 323 (22%)	0·95 (0·91–0·99)	0·01	0·89 (0·85–0·93)	<0·0001
Third quintile	4450 (16%)	27 859 (20%)	1·02 (0·97–1·06)	0·45	0·89 (0·85–0·93)	<0·001
Fourth quintile	4965 (17%)	22 353 (16%)	1·43 (1·37–1·49)	<0·0001	1·08 (1·03–1·13)	0·001
Fifth quintile (lowest)	8473 (30%)	25 433 (18%)	2·18 (2·09–2·26)	<0·0001	1·2 (1·14–1·25)	<0·0001
Tuberculosis						
Place of birth and parents' place of birth						
Born in Sweden and parents born in Sweden	282 (9%)	10 639 (69%)	1 (ref)	..	1 (ref)	..
Born in Sweden and at least one parent born abroad	79 (3%)	1814 (12%)	1·88 (1·44–2·46)	<0·0001	1·59 (1·21–2·10)	0·001
Born abroad	2703 (88%)	2867 (19%)	40 (34–47)	<0·0001	22 (19–26)	<0·0001
Education						
Post-secondary school	778 (25%)	6049 (39%)	1 (ref)	..	1 (ref)	..
Higher secondary school	952 (31%)	7171 (47%)	1·06 (0·96–1·18)	0·23	1·17 (1·03–1·34)	0·02
Lower secondary school or less	1334 (44%)	2100 (14%)	5·22 (4·69–5·80)	<0·0001	2·14 (1·85–2·47)	<0·0001
Employment status						
Employed	1475 (48%)	13 217 (86%)	1 (ref)	..	1 (ref)	..
Unemployed	1589 (52%)	2103 (14%)	7·02 (6·42–7·69)	<0·0001	1·88 (1·65–2·14)	<0·0001
Income§						
First quintile (highest)	129 (4%)	3101 (20%)	1 (ref)	..	1 (ref)	..
Second quintile	181 (6%)	3402 (22%)	1·41 (1·11–1·78)	0·004	1·13 (0·85–1·48)	0·39
Third quintile	285 (9%)	3192 (21%)	2·47 (1·98–3·08)	<0·0001	1·38 (1·06–1·79)	0·01
Fourth quintile	516 (17%)	2634 (17%)	5·69 (4·62–7·01)	<0·0001	2·06 (1·60–2·65)	<0·0001
Fifth quintile (lowest)	1953 (64%)	2991 (20%)	20 (16–24)	<0·0001	3·17 (2·49–4·04)	<0·0001
Food-borne and water-borne infections (hepatitis A virus, campylobacteriosis, cryptosporidiosis, EHEC, listeriosis, giardiasis, amoebiasis, salmonellosis, shigellosis, and yersiniosis)						
Place of birth and parents' place of birth						
Born in Sweden and parents born in Sweden	76 016 (79%)	346 417 (72%)	1 (ref)	..	1 (ref)	..
Born in Sweden and at least one parent born abroad	10 774 (11%)	50 978 (11%)	0·95 (0·93–0·97)	<0·0001	1 (0·98–1·02)	0·89
Born abroad	9165 (10%)	82 380 (17%)	0·50 (0·49–0·51)	<0·0001	0·6 (0·59–0·62)	<0·0001

(Table 4 continues on next page)

	Cases	Controls	Unadjusted comparison		Adjusted comparison	
			mOR (95% CI)	p value	amOR (95% CI)	p value
(Continued from previous page)						
Education						
Post-secondary school	38 286 (40%)	171 040 (36%)	1 (ref)	..	1 (ref)	..
Higher secondary school	46 501 (48%)	230 634 (48%)	0·89 (0·87–0·90)	<0·0001	0·94 (0·92–0·95)	0·0001
Lower secondary school or less	11 168 (12%)	78 101 (16%)	0·61 (0·60–0·62)	<0·0001	0·75 (0·73–0·77)	<0·0001
Employment status						
Employed	87 661 (91%)	408 864 (85%)	1 (ref)	..	1 (ref)	..
Unemployed	8294 (9%)	70 911 (15%)	0·54 (0·52–0·55)	<0·0001	0·74 (0·72–0·76)	<0·0001
Income¶						
First quintile (highest)	31 422 (33%)	116 594 (24%)	1 (ref)	..	1 (ref)	..
Second quintile	23 478 (24%)	107 659 (22%)	0·78 (0·77–0·80)	<0·0001	0·81 (0·80–0·83)	<0·0001
Third quintile	17 670 (18%)	93 851 (20%)	0·66 (0·65–0·68)	<0·0001	0·71 (0·70–0·73)	<0·0001
Fourth quintile	12 227 (13%)	75 801 (16%)	0·56 (0·55–0·57)	<0·0001	0·64 (0·63–0·66)	<0·0001
Fifth quintile (lowest)	11 158 (12%)	85 870 (18%)	0·45 (0·43–0·46)	<0·0001	0·59 (0·58–0·61)	<0·0001

Data are presented as number (%) unless otherwise specified. mOR=matched odds ratio. amOR=adjusted matched odds ratio. iGAS=invasive group A β-haemolytic streptococci. ESBL=extended spectrum β-lactamase-producing Enterobacteriaceae. MRSA=methicillin-resistant *Staphylococcus aureus*. VRE=vancomycin-resistant enterococci. PNSP=*Streptococcus pneumoniae* with reduced sensitivity to penicillin. EHEC=enterohaemorrhagic *Escherichia coli*. *Income linear trend: mOR 1·98, 95% CI 1·96–2·01, p<0·0001; amOR 1·41, 95% CI 1·39–1·43, p<0·0001; mean variance inflation factor (VIF) 1·60. †Income linear trend: mOR 1·18, 95% CI 1·15–1·20, p<0·0001; amOR 1·13, 95% CI 1·11–1·15, p<0·0001; mean VIF 1·44. ‡Income linear trend: mOR 1·23, 95% CI 1·22–1·24, p<0·0001; amOR 1·05, 95% CI 1·04–1·06, p=0·001; mean VIF 1·48. §Income linear trend: mOR 2·38, 95% CI 2·28–2·48, p<0·0001; amOR 1·38, 95% CI 1·31–1·45, p<0·0001; mean VIF 1·65. ¶Income linear trend: mOR 0·82, 95% CI 0·82–0·83, p<0·0001; amOR 0·87, 95% CI 0·87–0·88, p<0·0001; mean VIF 1·42.

Table 4: **Matched odds ratios by socioeconomic indicators among cases with blood-borne infections, invasive infectious diseases, antibiotic-resistant infections, tuberculosis, and food-borne and water-borne infections, and controls, Sweden, 2005–14**

between iGAS infection, invasive *H influenzae* disease, and MRSA infection and unemployment and low income was also evident, although we found no association with lower education. PNSP was associated only with unemployment, and no associations were found for invasive meningococcal disease (table 5).

Conversely, higher education, employment, and income were associated with higher notifications of food-borne and water-borne infectious diseases (table 4). Similar associations were found between higher education, employment, and income and shigellosis, yersiniosis, campylobacteriosis, and cryptosporidiosis. We also found an association between EHEC infection and employment and higher income, giardiasis and higher education and higher income, salmonellosis and employment and higher income, and amoebiasis and higher education. By contrast, HAV infection was associated with lower income, listeriosis and amoebiasis with unemployment, and salmonellosis with lower education (table 5). The stratified analyses based on whether food-borne and water-borne infectious diseases were acquired domestically or abroad are reported in the appendix.

For the nine other infectious diseases that we did not group, associations with at least one low socioeconomic indicator, and no associations with high socioeconomic indicators, were found for tuberculosis (associated with low education, unemployment, and low income), legionellosis (associated with low education and unemployment), and mycobacteriosis (associated with unemployment; table 5).

Associations with at least one high socioeconomic indicator, and no associations with low socioeconomic indicators, were found for dengue (associated with high education, employment, and high income) and pertussis (associated with high education). Malaria, nephropathia epidemica caused by Puumala virus, tularaemia, amoebiasis, and viral meningoencephalitis were associated with at least one low socioeconomic indicator and at least one high socioeconomic indicator (table 5).

Discussion

Our findings indicate three main patterns of association: a first group of infections and infectious diseases that are positively associated with all or most of the indicators of low socioeconomic conditions; a second group of infections and infectious diseases that are negatively associated with all or most of the indicators of low socioeconomic conditions; and a third group of infections and infectious diseases that have a positive association with some of the indicators and a negative association with other indicators. Invasive meningococcal disease was the only disease with no association with socio-economic indicators.

The occurrence of tuberculosis, atypical mycobacteriosis, HAV, HBV, and HCV infection, antibiotic-resistant infections, malaria, legionellosis, and listeriosis were associated with low socioeconomic indicators. These findings are in line with previous studies. Several studies have shown examples of infectious diseases dis-

	Born abroad *vs* born in Sweden by parents born in Sweden		Lower secondary education or less *vs* post-secondary education		Employed *vs* unemployed		Income in the fifth quintile (lowest) *vs* income in the first quintile (highest)	
	aMOR (95% CI)	p value	aMOR (95% CI)	p value	aMOR (95% CI)	p value	aMOR (95% CI)	p value
Tuberculosis	22 (19–26)	<0·0001	2·14 (1·85–2·47)	<0·0001	1·88 (1·65–2·47)	<0·0001	3·17 (2·49–4·04)	<0·0001
Hepatitis B virus infection	13 (12–14)	<0·0001	2·25 (2·05–2·46)	<0·0001	2·09 (1·93–2·51)	<0·0001	2·20 (1·93–2·51)	<0·0001
Hepatitis C virus infection	0·67 (0·64–0·71)	<0·0001	4·60 (4·32–4·91)	<0·0001	4·36 (4·16–4·58)	<0·0001	4·32 (3·99–4·68)	<0·0001
Invasive pneumococcal disease	0·56 (0·51–0·62)	<0·0001	1·40 (1·28–1·53)	<0·0001	1·56 (1·44–1·69)	<0·0001	1·57 (1·41–1·75)	<0·0001
Invasive group A streptococcal infection	0·54 (0·46–0·64)	<0·0001	0·92 (0·79–1·08)	0·32	1·72 (1·49–2·00)	<0·0001	1·47 (1·22–1·77)	<0·0001
Invasive *Haemophilus influenzae* disease	0·56 (0·41–0·76)	0·0003	1·24 (0·93–1·66)	0·15	1·77 (1·37–2·29)	<0·0001	1·33 (0·92–1·91)	0·12
Invasive meningococcal disease	0·80 (0·54–1·20)	0·29	0·93 (0·61–1·42)	0·75	1·14 (0·82–1·59)	0·44	1·17 (0·77–1·77)	0·46
MRSA infection	2·60 (2·45–2·76)	<0·0001	1·01 (0·94–1·09)	0·76	1·59 (1·48–1·70)	<0·0001	1·56 (1·43–1·71)	<0·0001
PNSP infection	1·29 (1·08–1·55)	0·005	0·83 (0·68–1·03)	0·09	1·72 (1·42–2·09)	<0·0001	1·01 (0·79–1·30)	0·92
VRE infection	0·91 (0·71–1·16)	0·45	1·69 (1·28–2·22)	<0·0001	3·02 (2·41–3·79)	<0·0001	1·61 (1·17–2·23)	0·004
ESBL infection	1·94 (1·87–2·02)	<0·0001	1·10 (1·05–1·16)	<0·0001	1·75 (1·68–1·83)	<0·0001	1·07 (1·01–1·13)	0·01
Atypical mycobacteria	1·60 (1·36–1·87)	<0·0001	1·03 (0·86–1·23)	0·76	2·14 (1·82–2·52)	<0·0001	0·99 (0·79–1·24)	0·94
Legionellosis	0·79 (0·59–1·04)	0·09	1·36 (1·05–1·76)	0·02	1·30 (1·01–1·67)	0·04	0·74 (0·52–1·04)	0·08
Hepatitis A virus infection	1·33 (0·98–1·80)	0·06	0·84 (0·58–1·21)	0·35	0·92 (0·65–1·31)	0·66	1·65 (1·13–2·43)	0·01
Listeriosis	1·39 (0·84–2·31)	0·20	1·40 (0·82–2·39)	0·22	3·07 (1·87–5·04)	<0·0001	1·03 (0·50–2·09)	0·94
Malaria	5·90 (4·70–7·39)	<0·0001	0·75 (0·57–1·00)	0·052	1·02 (0·79–1·32)	0·87	1·88 (1·36–2·61)	<0·0001
Nephropathia epidemica	0·56 (0·47–0·66)	<0·0001	1·19 (1·05–1·34)	0·005	0·83 (0·73–0·94)	0·003	1·15 (1·00–1·31)	0·01
Tularaemia	0·50 (0·40–0·61)	<0·0001	0·77 (0·65–0·91)	0·002	0·58 (0·49–0·70)	<0·0001	1·02 (0·84–1·23)	0·87
Amoebiasis	1·90 (1·60–2·63)	<0·0001	0·73 (0·59–0·91)	0·005	1·30 (1·06–1·60)	0·01	1·51 (1·19–1·91)	0·001
Viral meningoencephalitis	0·49 (0·44–0·55)	<0·0001	1·00 (0·89–1·11)	0·99	0·82 (0·73–0·92)	0·001	1·01 (0·89–1·14)	0·90
Pertussis	0·89 (0·76–1·04)	0·15	0·71 (0·59–0·86)	0·0003	0·91 (0·77–1·09)	0·31	0·82 (0·67–1·00)	0·052
Dengue	0·73 (0·58–0·90)	0·004	0·47 (0·35–0·63)	<0·0001	0·68 (0·51–0·89)	0·006	0·52 (0·40–0·67)	<0·0001
EHEC infection	0·94 (0·80–1·10)	0·44	1·06 (0·90–1·26)	0·47	0·76 (0·64–0·91)	0·003	0·79 (0·65–0·96)	0·02
Giardiasis	0·92 (0·84–1·00)	0·047	0·55 (0·50–0·61)	<0·0001	0·91 (0·83–1·00)	0·06	1·01 (0·91–1·11)	0·86
Salmonellosis	0·68 (0·64–0·72)	<0·0001	1·06 (1·01–1·12)	0·01	0·64 (0·60–0·67)	<0·0001	0·54 (0·51–0·57)	<0·0001
Shigellosis	0·97 (0·87–1·08)	0·58	0·45 (0·39–0·52)	<0·0001	0·66 (0·57–0·75)	<0·0001	0·71 (0·62–0·81)	<0·0001
Yersiniosis	0·88 (0·76–1·03)	0·11	0·58 (0·49–0·69)	<0·0001	0·61 (0·51–0·74)	<0·0001	0·54 (0·45–0·65)	<0·0001
Campylobacteriosis	0·49 (0·47–0·50)	<0·0001	0·69 (0·66–0·71)	<0·0001	0·75 (0·72–0·77)	0·0003	0·54 (0·52–0·56)	<0·0001
Cryptosporidiosis	0·20 (0·15–0·26)	<0·0001	0·66 (0·53–0·82)	0·0002	0·73 (0·58–0·92)	0·007	0·66 (0·53–0·81)	<0·0001

amOR=adjusted matched odds ratio. MRSA=meticillin-resistant *Staphylococcus aureus*. PNSP=*Streptococcus pneumoniae* with reduced sensitivity to penicillin. VRE=vancomycin-resistant enterococci. ESBL=extended spectrum β-lactamase-producing Enterobacteriaceae. EHEC=enterohaemorrhagic *Escherichia coli*.

***Table 5:* Adjusted matched odds ratios by socioeconomic indicators in cases with one of 29 infectious diseases and controls, Sweden, 2005–14**

proportionally affecting disadvantaged groups or deprived areas in Europe.[11,12] Increased antibiotic resistance to *E coli* and community-associated MRSA transmission have been, for instance, associated with neighbourhood deprivation in the UK.[13,14] We speculate that lower socioeconomic conditions could lead to higher occurrence of infectious diseases via several pathways. Lower income might affect living conditions through poor housing, overcrowding, poor nutrition, residence in deprived neighbourhoods, and unsatisfactory hygiene. Lower education might result in precarious working conditions, unhealthy lifestyles (eg, smoking, alcohol abuse, and lower exercise), scarce health education and knowledge, and reduced immunisation. Unemployment might predispose to infectious diseases through personal economic instability, personal exploitation, erosion of social participation and social inclusion, depression, and engagement in unhealthy lifestyles (eg, alcohol abuse).

In our study, most of the food-borne and water-borne infections and infectious diseases (shigellosis, yer-

siniosis, campylobacteriosis, tularaemia, EHEC infection, salmonellosis, cryptococcosis, and giardiasis), but also dengue, pertussis, and viral meningo-encephalitis, were negatively associated with low socioeconomic factors. These associations have been previously explored by other studies[15] that, mostly, used geospatial analysis for the assessment of socioeconomic status. Even if some studies in high-income countries reported an association between food-borne and water-borne diseases and low socioeconomic status,[16] other studies reported an association with higher socioeconomic status.[15]

A meta-analysis[17] on consumer food safety knowledge and practices indicated that knowledge of good practices to prevent cross-contamination exceeded their application in people with higher education, whereas in people with low income and in those without a high school education, the use of hygiene practices exceeded their knowledge. The same study also reported that consumers in the high-income category consumed more raw or undercooked ground beef and shellfish, which are associated with food-borne infections, and were the least knowledgeable about good hygiene practices and practices to prevent cross-contamination.

A Danish study[18] based on individual data indicated, similarly to our study, an association between bacterial food-borne and water-borne infections and higher socioeconomic factors. The Danish study suggested that one of the possible explanations for this association was a higher predisposition for international travel among affluent segments of the population. However, this explanation could not be confirmed, since the place of infection was not systematically included in the analysis. In our study, we identified associations between higher socioeconomic factors and water-borne and food-borne infections when acquired abroad, whereas these associations were not always identified when the infections were acquired in Sweden. Furthermore, for dengue that was not autochthonous in Sweden, travel patterns might also have influenced the negative association with low socioeconomic factors, because individuals of higher socioeconomic status might be more likely to travel to dengue-endemic areas.

Invasive pneumococcal disease, iGAS infection, invasive *H influenzae* disease, nephropathia epidemica, and amoebiasis were variably associated with different socioeconomic indicators. Invasive pneumococcal disease, iGAS infection, and invasive *H influenzae* disease were negatively associated with being born abroad, but positively associated with at least one of the factors linked to low socioeconomic status.

Considering that other comorbidities and chronic illnesses are risk factors for invasive pneumococcal disease, iGAS infection, and invasive *H influenzae* disease,[19–21] the self-selection of healthy immigrants before migration resulting in immigrants being healthier than the host population (healthy immigrant effect)[22] might explain the protective association with being born abroad. At the same time, the association between invasive pneumococcal disease, iGAS infection, and invasive *H influenzae* disease and chronic conditions, which in turn are associated with low socioeconomic status,[3] might explain the association with other measurements of socioeconomic deprivation.

The association of nephropathia epidemica with lower education and lower income and the protective association of unemployment might suggest a professional exposure linked to lower education and income. A Finnish serological study[23] indicated that, compared with other groups, farmers can contract infections earlier and more frequently, probably because of more frequent exposure to the indoor air of farm buildings and stored hay locations that are often visited by rodents.[23]

In our analysis, we used different socioeconomic factors that are often considered to be inter-related, such as employment status, income, and education. This simultaneous use raised concerns that the analysis could have been affected by collinearity. However, the VIF for each model was consistently low (table 4). This low VIF confirmed previous evidence that correlation among different socioeconomic measurements is not strong enough to prevent them from being analysed together, and these factors are therefore not interchangeable.[24] Furthermore, this low VIF suggests that education, employment, and household income can influence health outcomes along different pathways,[24] and they therefore provide different opportunities for prevention.

Our research did not evaluate specific interventions aimed to reduce health inequalities in infectious diseases; therefore, no specific recommendations to this end can be made from our work. However, evidence-based strategies and best practices aimed to minimise health inequalities associated with infectious diseases have been proposed in the scientific literature and have also been highlighted in technical reports of specialised agencies.[11,25] Overall, addressing health inequalities cannot rely on a single resolutive intervention but requires integrated, comprehensive, context-adapted strategies acting upon structural, intermediate, and more proximal determinants of health.

A pillar of those strategies is data collection and analyses to document and assess the extent of health inequalities in a society, as done in this study. Since the reduction of socioeconomic inequalities in health is often achieved not only through interventions that directly fall under public health but often through a broader political vision, our findings have two possible uses. For several of the infectious diseases that we studied, our research provided the most recent association with socioeconomic indicators, measured on a national scale. This approach is novel given that most previous studies focused on specific risks groups or specific disadvantaged geographical areas.[11] The results of our study might be of interest, particularly for policy makers, given that the findings of this research provide an overview of the socioeconomic inequalities in infectious diseases across the whole of Swedish society, meaning that informed decisions could be taken for political prioritisation. Additionally, our approach is straightforward, easily reproducible (at least in Sweden), and relatively inexpensive. By using our findings as a baseline, monitoring the changes in inequalities linked to infectious diseases over time could be possible, and therefore, so too could assessing the efficacy and impact of national policies and interventions.

Although based on regularly updated individual data, this study had some limitations that should be taken into account when interpreting its findings. First, we included only laboratory-confirmed cases of notified infectious diseases. Notifications underestimate the total number of cases because of variable health-care seeking behaviour across different groups of the population, which is in turn influenced by, among other factors, disease severity, socioeconomic conditions,[26,27] and different testing patterns.

Second, Statistics Sweden estimated that around 500 000 unregistered couples without children cannot be linked to the same family. Furthermore, in our study we could not link in the same family more than two generations of individuals. These elements probably affected the accuracy of the estimation of the equivalised income of both cases and controls.

Third, the large sample size and high frequency of testing might have inflated the overall type 1 error, although CIs were narrow and p values were largely lower than 0·05 for most of the associations we identified. Additionally, the associations were generally consistent within the same groups of infections. Only one disease showed no association with the examined socioeconomic indicators. All these elements suggest that most of the associations were not the results of chance.

Fourth, our research did not take into account severity and outcome of the episodes of infectious diseases. Exploring possible correlations between the severity of several infectious diseases and socioeconomic status could be the scope of further research. Finally, given that in this study we included only individuals aged 18–65 years, our findings cannot be extrapolated to children, adolescents, or the older population.

Our study indicates the existence of socioeconomic inequalities that are linked to some of the most notified infections and infectious diseases in Sweden. Even if our study did not examine associations between infectious diseases and socioeconomic factors in specific groups, we recommend using these data to identify priority interventions to lessen the burden of these diseases and as a baseline to monitor programmes aimed to address socioeconomic inequalities in health. Other than for Sweden, these findings might be of interest for other high-income countries in Europe, where reducing health inequalities represents a goal for their authorities.

Contributors

AP, AT, and AW conceived the study. AP, MS, KD, and AW developed the research idea. AP, AT, and AW obtained the data from Statistics Sweden. AP, IG, and HK developed and led the statistical analysis. AP drafted the article and all authors commented on and approved the final version. AW oversaw the entire research.

Declaration of interests

We declare no competing interests.

References

1 UCL Institute of Health Equity. Review of social determinants and the health divide in the WHO European Region: final report. Copenhagen, WHO Regional Office for Europe, 2014. http://www.euro.who.int/_data/assets/pdf_file/0004/251878/Review-of-social-determinants-and-the-health-divide-in-the-WHO-European-Region-FINAL-REPORT.pdf (accessed Nov 29, 2018).

2 Mackenback JP, Karanikolos M, McKee M. The unequal health of Europeans: successes and failures of policies. *Lancet* 2013; **381:** 1125–34.

3 Di Cesare M, Khang YH, Asaria P, et al. Inequalities in non-communicable diseases and effective responses. *Lancet* 2013; **381:** 585–97.

4 Organization for Economic Cooperation and Development. Compare your country income distribution and poverty. http://www.compareyourcountry.org/inequality?cr=oecd&lg=en (accessed Sept 30, 2017).

5 Anell A, Glenngård AH, Merkur S. Health systems in transition. Sweden: health system review. Geneva: World Health Organization, 2012.

6 Ludvigsson JF, Otterblad-Olausson P, Pettersson BU, Ekbom A. The Swedish personal identity number: possibilities and pitfalls in healthcare and medical research. *Eur J Epidemiol* 2009; **24:** 659–67.

7 Ludvigsson JF, Amqvist C, Edstedt Bonamy A-K, et al. Registers of the Swedish total population and their use in medical research. *Eur J Epidemiol* 2016; **31:** 125–36.

8 Folkhalsomyndigheten. Falldefinitioner vid anmälan enligt smittskyddslagen. https://www.folkhalsomyndigheten.se/contentassets/d109fac1689846edb6ce7292c0588e39/falldefinitioner-anmalan-smittskyddslagen-01209-2017.pdf (accessed July 6, 2018).

9 Rolfhamre P, Jansson A, Arneborn M, Ekdahl K. SmiNet-2: description of an internet-based surveillance system for communicable diseases in Sweden. *Euro Surveill* 2006; **11:** 103–07.

10 Statisc Sweden. Longitdinell integrationsdatabas for sjukforsakrings och arbetsmarknadsstudier (LISA) 1990–2009. https://www.scb.se/statistik/_publikationer/AM9901_1990I09_BR_AM76BR1104.pdf (accessed Nov 11, 2018).

11 JC Semenza, J Giesecke. Intervening to reduce inequalities in infections in Europe. *Am J Public Health* 2008; **98:** 787–92.

12 JC Semenza. Strategies to intervene on social determinants of infectious diseases. *Euro Surveill* 2010; **15:** 32–39.

13 Nomamiukor BO, Horner C, Kirby A, Hughes GJ. Living conditions are associated with increased antibiotic resistance in community isolates of *Escherichia coli*. *J Antimicrob Chemother* 2015; **70:** 3154–58.

14 Tosas Auguet O, Betley JR, Stabler RA, et al. Evidence for community transmission of community-associated but not health-care-associated methicillin-resistant *Staphylococcus aureus* strains linked to social and material deprivation: spatial analysis of cross-sectional data. *PLoS Med* 2016; **26:** 13.

15 Newman KL, Leon JS, Rebolledo PA, Scallan E. The impact of socioeconomic status on foodborne illness in high income countries: a systematic review. *Epidemiol Infect* 2015; **143:** 2473–85.

16 Quinlan JJ. Foodborne illness incidence rates and food safety risks for populations of low socioeconomic status and minority race/ethnicity: a review of the literature. *Int J Environ Res Public Health* 2013; **10:** 3634–52.

17 Patil SR, Cate S, Morales R. Consumer food safety knowledge, practices, and demographic differences: findings from a meta-analysis. *J Food Prot* 2005; **68:** 1884–94.

18 Simonsen J, Frisch M, Ethelberg S. Socioeconomic risk factors for bacterial gastrointestinal infections. *Epidemiology* 2008; **19:** 282–90.

19 Centers for Disease Control and Prevention. *Haemophilus influenza* disease (including Hib). 2016. https://www.cdc.gov/hi-disease/clinicians.html (accessed April 1, 2017).

20 Backhaus E, Berg S, Andersson R, et al. Epidemiology of invasive pneumococcal infections: manifestations, incidence and case fatality rate correlated to age, gender and risk factors. *BMC Infect Dis* 2016; **16:** 367.

21 Nelson GE, Pondo T, Toews KA, et al. Epidemiology of invasive group A streptococcal infections in the United States, 2005–2012. *Clin Infect Dis* 2016; **63:** 478–86.

22 Constant AF, Garcia-Munoz T, Neuman S, Neuman T. A "healthy immigrant effect" or a "sick immigrant effect"? Selection and policies matter. *Eur J Health Econ* 2018; **19:** 103–21.

23 Vapalahti K, Paunio M, Brummer-Korvenkontio M, Vaheri A, Vapalahti O. Puumala virus infections in Finland: increased occupational risk for farmers. *Am J Epidemiol* 1999; **149:** 1142–51.

24 Braveman PA, Cubbin C, Egerter S, et al. Socioeconomic status in health research: one size does not fit all. *JAMA* 2005; **294:** 2879–88.

25 European Centre for Disease Prevention and Control. Health inequalities, the financial crisis, and infectious diseases in Europe. Stockholm: European Centre for Disease Prevention and Control, 2013.

26 Wamala S, Merlo J, Bostrom G, Hogstedt C. Perceived discrimination, socioeconomic disadvantage and refraining from seeking medical treatment in Sweden. *J Epidemiol Community Health* 2007; **61:** 409–15.

27 Agerholm J, Bruce D, Ponce de Leon A, Burstrom B. Socioeconomic differences in healthcare utilization, with and without adjustment for need: an example from Stockholm, Sweden. *Scand J Public Health* 2013; **41:** 318–25