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Neighborhood Deprivation and Risk of Age-Related Eye Diseases: A Follow-up Study in Sweden

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Abstract

Purpose—To examine whether there is an association between neighborhood deprivation and age-related eye diseases, particularly macular degeneration, cataract, diabetes-related eye complications, and glaucoma.

Methods—The study population comprised a nationwide sample of 2,060,887 men and 2,250,851 women aged 40 years or older living in Sweden who were followed from 1 January 2000 until the first hospitalization/outpatient registration for age-related eye disease during the study period, death, emigration, or the end of the study period on 31 December 2010. Multilevel logistic regression was used to estimate the association between neighborhood deprivation and age-related eye diseases.

Results—In men, the odds ratio (OR) for age-related eye diseases for those living in high-deprivation neighborhoods compared to those living in low-deprivation neighborhoods remained significant after adjustment for potential confounding factors (macular degeneration, OR 1.08, 95% confidence interval, CI, 1.03–1.12; cataract, OR 1.31, 95% CI 1.26–1.35; diabetes-related eye complications, OR 1.36, 95% CI 1.30–1.43; glaucoma, OR 1.11, 95% CI 1.06–1.15). In women, similar patterns were observed (macular degeneration, OR 1.11, 95% CI 1.07–1.15;

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DECLARATION OF INTEREST

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cataract, OR 1.36, 95% CI 1.31–1.40; diabetes-related eye complications, OR 1.50, 95% CI 1.42–1.59; glaucoma, OR 1.12, 95% CI 1.08–1.17).

Conclusion—Our results suggest that neighborhood deprivation is associated with age-related eye diseases in both men and women. These results implicate that individual- as well as neighborhood-level factors are important for preventing age-related eye diseases.

Keywords

age-related eye diseases; neighborhood deprivation; multilevel analysis; epidemiology; preventive medicine

INTRODUCTION

Age-related eye diseases, particularly macular degeneration, cataract, diabetes-related eye complications, and glaucoma, are considered to be major public health concerns, and the most common causes of visual impairment among adults.¹ Previous studies have identified potential risk factors, including age, sex, ethnicity, smoking, obesity, diet, low income, low educational attainment, ultraviolet B radiation, intraocular pressure and certain genetic variants.^{1–7}

In contrast to individual-level socioeconomic measures, such as income and education, neighborhood deprivation is a socioeconomic feature of the neighborhood environment that has often been defined based on the proportion of residents with low socioeconomic status, unemployed people and/or people receiving welfare assistance.^{8–12} A growing body of research is targeting the effect of neighborhood deprivation on health, including coronary heart disease, cancer, and hospitalization for atrial fibrillation.^{13–16} Some studies have examined the association between neighborhood deprivation and eye diseases. In a Scottish study, neighborhood deprivation was associated with severity of glaucoma, with patients from areas of higher neighborhood deprivation presenting with more advanced glaucoma.¹⁷ In the United Kingdom, a significant association between acute primary angle closure and higher levels of neighborhood deprivation was observed.¹⁸ Furthermore, Yip et al found that people with low vision were more likely to live in the most deprived areas.¹⁹ These previous studies used an aggregated deprivation index that allows tests of potential influences on health-related outcomes beyond individual-level socioeconomic status. However, to the best of our knowledge, no previous large-scale multilevel study has investigated whether neighborhood deprivation is associated with age-related eye diseases, including macular degeneration, cataract, diabetes-related eye complications, and glaucoma.

The first aim of this nationwide multilevel study was to examine whether neighborhood-level deprivation was associated with age-related eye diseases, including macular degeneration, cataract, diabetes-related eye complications, and glaucoma. The second aim was to test whether these possible associations remained significant after adjustment for age, educational attainment, marital status, family income, immigrant status, and region of residence and comorbidities.

MATERIALS AND METHODS

Data source

The data sources in this study come from several Swedish national registers. The registers used in this study were the Total Population Register, the Hospital Discharge Register, and the Outpatient Register. The Swedish nationwide population and health care registers have exceptionally high completeness and validity.²⁰ The validity of the Hospital Discharge Register is high, and coverage of data from public caregivers is almost 100% in the Outpatient Register, that is, this register has very few missing data.²¹

All data linkages were performed by the use of an individual national identification number that is assigned to each person in Sweden for his or her lifetime. This identification number was replaced by a serial number for analysis in order to provide anonymity. The follow-up period in this study ranged from 1 January 2000 until the first hospitalization or outpatient registration for age-related eye disease during the study period, death, emigration, or the end of the study period on 31 December 2010. The study population comprised a nationwide sample of 2,060,887 men and 2,250,851 women aged 40 years or older.

Age-related eye diseases

The outcome variable in this study was first age-related eye disease during the study period. Sweden has universal health care that is provided to the population at a very low cost. For example, the maximum cost per year for outpatient care is 1,100 Swedish krona (EUR113 or US\$146). Preventive eye examinations for screening purposes are included on a regular basis for patients with diabetes mellitus. Ophthalmological diseases are mainly diagnosed by specialists in inpatient or outpatient clinics. Data regarding inpatient or outpatient diagnoses of age-related eye diseases were retrieved from the Hospital Discharge Register (2000–2010) or Outpatient Register (2001–2010), respectively. These registers include information regarding all hospital visits, including diagnoses. We searched the Hospital Discharge Register and Outpatient Register for the International Classification of Diseases revision 10 (ICD-10) codes denoting age-related eye disease as the primary or secondary diagnosis during the study period. In this study, macular degeneration (ICD-10 H35.3), cataract (ICD-10 H25), diabetes-related eye complications (ICD-10 E11.3, H28.0, H36.0), and glaucoma (ICD-10 H40.0, H40.1, H40.2) were defined as age-related eye diseases.²² The serial numbers were used to ensure that each individual appeared only once in the dataset for his or her first hospital diagnosis of age-related eye disease during the study period, and individuals with pre-existing age-related eye disease were excluded. A total of 707,341 age-related eye disease cases were identified during the follow-up period.

Neighborhood deprivation index

A summary measure was used to characterize neighborhood-level deprivation. The home addresses of all Swedish individuals were geocoded to small geographic units with boundaries defined by homogeneous building types. These neighborhood areas, called small area market statistics (SAMS), have an average of 1,000 residents. SAMS were used as proxies for neighborhoods, as they were in previous research.⁸

We used deprivation indicators, similar to those used by the government of the UK (<https://www.gov.uk/government/statistics/english-indices-of-deprivation-2010>), to characterize neighborhood environments. We then performed a principal component analysis to select deprivation indicators in the Swedish national database. The following 4 variables were selected for individuals aged 25–64 years because this age group represents those who are among the most socioeconomically active in the population (ie, a population group that is assumed to have a stronger impact on the socioeconomic structure of the neighborhood than children, younger people, and retirees have); low educational level (<10 years of formal education), low income (income from all sources, including that from interest and dividends, <50% of median individual income), unemployment (excluding full-time students, those completing military service, and early retirees), and receipt of social welfare. Social welfare is provided to those individuals who cannot support themselves and are without any assets. It could sometimes include unemployed people who haven't signed up for unemployment benefits. Each of the 4 variables was loaded on the first principal component with similar loadings (+0.47 to +0.53) and explained 52% of the variation between these variables. A z score was calculated for each SAMS neighborhood. The z scores, weighted by the coefficients for the eigenvectors, were then summed to create the index.²³ The index was categorized into 3 groups; below 1 standard deviation (SD) from the mean (low deprivation), above 1 SD from the mean (high deprivation), and within 1 SD of the mean (moderate deprivation).

Other variables

Age (40 years or older), sex (male or female), marital status (grouped as 1. married/cohabitating, 2. never married, widowed or divorced), family income, educational attainment, immigrant status, region of residence, and comorbidities were included in this study. Family income was calculated as annual family income divided by the number of people in the family. Family income took into consideration ages of the family members and used a weighted system whereby small children were given lower weights than adolescents and adults. The sum of all family members' incomes was multiplied by the individual's consumption weight divided by the family members' total consumption weight. Educational attainment was categorized as completion of compulsory school or less (<9 years), practical high school or some theoretical high school (10–12 years), and completion of theoretical high school and/or college/university (>12 years). Practical high school includes vocational training to introduce students to certain trades, such as mechanics, health services or cosmetology, whereas theoretical high school prepares the students for college/university studies. Immigrant status was placed into 6 categories based on the most common immigrant groups in Sweden; 1. native-born, 2. born in Finland, 3. born in Western Europe or North America (ie, Denmark, UK, France, Italy, Germany, US, etc), 4. born in Eastern Europe (ie, Bosnia-Herzegovina, Yugoslavia, Czechoslovakia, Poland, Romania, Russia, etc), 5. born in the Middle East (ie, Turkey, Lebanon, Iran, Iraq, Morocco, North Africa, etc), and 6. all other nationalities. Those born in Finland were classified separately as they represent the largest immigrant group in Sweden. Region of residence was defined as follows; living in a large city, a middle-sized town, or a small town/rural area. Large cities were those with a population >200,000 (Stockholm, Gothenburg, and Malmö), middle-sized towns had a population >90,000 but <200,000, and small towns had a population >27,000 but <90,000.

Rural areas were areas with populations smaller than those of small towns. Comorbidity was defined as hospitalization (within 10 years before the start of the follow-up) for a main diagnosis of the following diseases; 1. chronic obstructive pulmonary disease (COPD; ICD-9 490–496 and ICD-10 J40–J49); 2. obesity (ICD-9 278A and 278B, and ICD-10 E65 and E66); 3. alcoholism and alcohol-related liver disease (ICD-9 291, 303, 571A, 571B, 571C, and 571D, and ICD-10 F10 and K70); 4. diabetes mellitus (ICD-9 250 and ICD-10 E10–E14); 5. hypertension (ICD-9 401–405, and ICD-10 I10–I15); 6. coronary heart disease (ICD-9 410–414, and ICD-10 I20–I25); 7. stroke (ICD-9 430–438, and ICD-10 I60–I69); and 8. dementia (ICD-10 F00, F01 and F03). These comorbidities and the sociodemographic variables were included in analyses as they may be associated with the outcome as well as confound the potential association between neighborhood deprivation and age-related eye diseases.

Statistical analysis

Multilevel logistic regression was performed with individuals at the first level and neighborhoods at the second level to derive odds ratios (ORs) with 95% confidence intervals (CIs) of age-related eye diseases. These models are considered to be a good approximation of Cox's proportional hazard models because we had a large sample size, a relatively low incidence rate, and risk ratios of moderate size.²⁴ Analyses were performed using MLwiN version 2.27 (Centre for Multilevel Modelling, University of Bristol, Bristol, UK). First, a model was created to determine the crude ORs of age-related eye diseases by levels of neighborhood deprivation (model 1). Next, a full model that included neighborhood-level deprivation, age, educational attainment, marital status, family income, immigrant status, region of residence, and comorbidities added simultaneously to the model was created (model 2). We also applied Cox regression models where we used robust standard errors to adjust the 95% CIs for clustering of individuals within areas. The effect sizes were very similar, which strengthens that our results are robust. The use of multilevel modeling made it possible for us to obtain estimates of intra class correlation, which were very low in all models. We were, due to convergence problems, unable to apply multilevel survival models in such a large dataset. However, additional analyses where we applied Cox regression models as well as ordinary logistic models were performed for comparison (see Supplementary Tables 1 and 2). Data for men and women were analyzed in separate models.

This study was approved by the Ethics Committee of Lund University, Sweden.

RESULTS

Table 1 shows the number of subjects in the study population with the number of age-related eye disease cases, and age-standardized incidence proportions by levels of neighborhood deprivation. Among the 4,311,738 subjects aged 40 years or older who had not developed age-related eye disease at baseline, 707,341 incident cases identified during the study period. The majority of age-related eye disease cases were cataract (54.6%), followed by macular degeneration (20.9%), glaucoma (17.3%), and diabetes-related eye complications (7.3%).

Table 2 shows the different models for age-related eye diseases. In the crude model (model 1) for men, ORs were significantly increased in those living in moderate deprivation

neighborhoods (OR 1.27, 95% CI 1.24–1.30) and high deprivation neighborhoods (OR 1.28, 95% CI 1.25–1.32). After adjustment for potential confounding factors, the ORs remained statistically significant (model 2). For women, similar patterns were observed.

Table 3 shows the different models for macular degeneration. In the crude model (model 1) for men, ORs were significantly increased in those living in moderate deprivation neighborhoods and high deprivation neighborhoods. After adjustment for potential confounding factors, the ORs remained statistically significant in those living in moderate deprivation neighborhoods (OR 1.07, 95% CI 1.04–1.10) and high deprivation neighborhoods (OR 1.08, 95% CI 1.03–1.12). For women, similar patterns were observed, with significantly higher ORs for macular degeneration for those living in neighborhoods with moderate (OR 1.09, 95% CI 1.06–1.12) and high (OR 1.11, 95% CI 1.07–1.15) deprivation (model 2).

Table 4 shows the different models for cataract. In the crude model (model 1) for men, ORs were significantly increased in those living in moderate deprivation neighborhoods and high deprivation neighborhoods. After adjustment for potential confounding factors, these ORs remained statistically significant in those living in moderate deprivation neighborhoods (OR 1.25, 95% CI 1.22–1.29) and high deprivation neighborhoods (OR 1.31, 95% CI 1.26–1.35). For women, similar patterns were observed, with significantly higher ORs for cataract for those living in neighborhoods with moderate (OR 1.30, 95% CI 1.27–1.34) and high (OR 1.36, 95% CI 1.31–1.40) deprivation (model 2).

Table 5 shows the different models for diabetes-related eye complications. In the crude model (model 1) for men, ORs were significantly increased in those living in moderate deprivation neighborhoods and high deprivation neighborhoods. After adjustment for potential confounding factors, these ORs remained statistically significant in those living in moderate deprivation neighborhoods (OR 1.22, 95% CI 1.17–1.27) and high deprivation neighborhoods (OR 1.36, 95% CI 1.30–1.43). For women, similar patterns were observed, with significantly higher ORs for diabetes-related eye complications for those living in neighborhoods with moderate (OR 1.29, 95% CI 1.23–1.35) and high (OR 1.50, 95% CI 1.42–1.59) deprivation (model 2).

Last, Table 6 shows the different models for glaucoma. In the crude model (model 1) for men, ORs were significantly increased in those living in moderate deprivation neighborhoods and high deprivation neighborhoods. After adjustment for potential confounding factors, the ORs were significantly increased in those living in moderate deprivation neighborhoods (OR 1.12, 95% CI 1.09–1.16) and high deprivation neighborhoods (OR 1.11, 95% CI 1.06–1.15). For women, similar patterns were observed, with significantly higher ORs for glaucoma for those living in neighborhoods with moderate (OR 1.14, 95% CI 1.11–1.17) and high (OR 1.12, 95% CI 1.08–1.17) deprivation (model 2).

Neighborhood deprivation explained 6% (men) and 8% (women) of the between-neighborhood variance in the crude model (Table 2, model 1). After inclusion of other variables, the explained variance increased to 28% and 29%, respectively (Table 2, model 2). Similar patterns were observed in Tables 3–6.

DISCUSSION

To the best of our knowledge, this is the first large-scale multilevel study to examine the potential effect of neighborhood deprivation on age-related eye diseases. The main finding of this study is that the ORs for age-related eye diseases were higher in both men and women living in deprived neighborhoods than those living in affluent neighborhoods. Our results are consistent with a recent study from Ng et al, indicating that neighborhood deprivation is associated with severity of glaucoma at presentation, with patients from areas of higher deprivation presenting with more advanced glaucoma.¹⁷ Our study includes large cohort data of approximately 4 million subjects, which increases the generalizability of the demonstrated association between neighborhood deprivation and age-related eye diseases. Also, low individual-level socioeconomic status may cumulatively load against individuals. That is, the most at-risk individuals would be those who are exposed to high neighborhood deprivation as well as having low socioeconomic status.

The causal pathways between neighborhood deprivation and age-related eye diseases remain unclear. One possible explanation could be psychological stress, due to violent crime, isolation or alienation, littering, and vandalism.^{25–27} It might be possible that these unsafe environments increase residents' stress and reduce their ability to have a healthy lifestyle. For example, previous studies have suggested that crime lies in the direct pathway between a neighborhood's social environment and health.^{28, 29} Other reasons are that socio-cultural norms regarding smoking, diet, and physical activity could vary between neighborhoods. For example, a Swedish study showed that cardiovascular disease risk factors including physical inactivity, obesity, and smoking were more common among individuals living in deprived neighborhoods than among those living in affluent neighborhoods.¹¹

Moreover, our results might be explained by differences in accessibility to healthcare facilities. In Sweden, universal medical care is provided to all permanent residents, and healthcare clinics and hospitals are equally distributed and located centrally in all types of neighborhoods.³⁰ However, the actual number of health professionals working in healthcare clinics can vary by neighborhood type. This is due to difficulties in recruiting and retaining healthcare personnel in high-deprivation neighborhoods. For example, a study of the turnover of general practitioners in the UK found that high deprivation neighborhoods had a higher turnover of general practitioners.³¹

Epidemiological studies focused on contextual effects, such as neighborhood deprivation in the present study, are important to consider for prevention of and control strategies for age-related eye diseases. Elderly people spend more time in their neighborhood compared with younger people. In this setting, individual-level factors, but also neighborhood-level factors are important for the prevention and control of age-related eye diseases. The identification of neighborhood-level factors is also essential for planning targeted group in clinical settings, such as primary health care.

The present study has a number of strengths. To our knowledge, this is the first large-scale study of an entire national population to examine the effect of neighborhood deprivation on age-related eye diseases. Furthermore, by using multilevel models, we could separate the

neighborhood effect on age-related eye diseases from individual effects, taking into consideration both fixed and random effects in the analyses. Finally, the use of small geographic units was well defined to capture neighborhood-level characteristics. This study also has several limitations. First, our data did not allow for the assessment of other important risk factors for age-related eye diseases (eg, smoking, obesity). However, we adjusted for comorbidities, such as hospitalization for chronic lower respiratory disease and obesity. Second, there are several neighborhood characteristics not assessed here, that may influence the health status of residents in deprived neighborhoods. For example, measures of neighborhood deprivation can be surrogates of multiple known and unknown factors, including social norms and social networks that may influence health-related behaviors. Third, our data did not include ICD-10 codes with more than 3 digits, that is, only 3 digits were available to us, such as H35.3 (see Supplementary Table 3). Fourth, the Swedish Outpatient Register has not been fully validated yet, whereas the Hospital Discharge Register has been extensively validated.²¹ Evaluations of the Swedish Outpatient Register have, however, found very few missing data³² and we have no reason to believe that the Outpatient Register is of poorer quality than the Hospital Discharge Register for eye diseases. This is because outpatients are mainly diagnosed by ophthalmologists in specialized outpatient care and both inpatient and outpatient care is linked to payment. Last, this study was confirmed to be the first of its kind in a Scandinavian country and further studies are needed to determine whether the findings can be generalized to other cultural settings.

In conclusion, our results suggest that neighborhood deprivation is associated with age-related eye diseases, ie, macular degeneration, cataract, diabetes-related eye complications, and glaucoma, in both men and women. These results imply that decision-makers and health care professionals should consider individual- as well as neighborhood-level factors in the prevention of age-related eye diseases.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Distribution of population, number of age-related eye disease events and age-standardized cumulative rates (per 100) by neighborhood deprivation, Sweden

	Population		Eye events		Neighborhood deprivation, %		
	n	%	n	%	Low	Moderate	High
Total population (%)	4,311,738				24 (n=1,012,818)	60 (n=2,607,832)	16 (n=691,088)
Total events			707,341		12.8	17.5	17.7
Age-related eye disease							
Macular degeneration			147,496	20.9	2.9	3.6	3.5
Cataract			386,163	54.6	6.6	9.6	9.9
Diabetes-related eye complications			51,317	7.3	0.9	1.2	1.5
Glaucoma			122,365	17.3	2.5	3.0	2.7
Register							
Hospital Discharge Register			15,180	2.1	0.3	0.4	0.4
Outpatient Register			692,161	97.9	12.5	17.1	17.3
Sex							
Male	2,060,887	47.8	282,467	39.9	11.7	15.3	15.3
Female	2,250,851	52.2	424,874	60.1	13.8	19.3	19.6
Age, years							
40–49	1,161,574	26.9	34,389	4.9	2.4	3.1	3.5
50–59	1,225,082	28.4	106,911	15.1	7.4	9.1	9.7
60–69	812,499	18.8	187,777	26.5	20.1	24.0	23.9
70–79	685,814	15.9	256,441	36.3	33.1	38.7	37.4
80	426,769	9.9	121,823	17.2	23.5	29.8	29.5
Educational attainment							
9 years	1,931,017	44.8	455,262	64.4	13.5	17.7	17.9
10–12 years	1,089,494	25.3	128,673	18.2	11.7	14.7	14.8
>12 years	1,291,227	29.9	123,406	17.4	10.1	13.5	13.6
Marital status							
Married/cohabiting	2,474,349	57.4	398,125	56.3	13.3	18.0	18.2
Never married, widowed, or divorced	1,837,389	42.6	309,216	43.7	12.4	17.0	17.2

	Population		Eye events		Neighborhood deprivation, %		
	n	%	n	%	Low	Moderate	High
Family income, quartiles							
Low income	1,081,986	25.1	203,232	28.7	13.0	17.3	17.4
Middle-low income	1,077,050	25.0	210,588	29.8	13.8	18.0	18.4
Middle-high income	1,075,248	24.9	159,151	22.5	13.2	17.7	17.8
High income	1,077,454	25.0	134,370	19.0	11.9	17.1	17.5
Country of birth							
Sweden	3,777,082	87.6	637,662	90.1	13.0	17.6	18.0
Finland	156,742	3.6	21,172	3.0	10.8	16.0	16.5
Western countries	45,534	1.1	7,607	1.1	11.0	16.3	16.9
Eastern European countries	68,438	1.6	7,032	1.0	10.0	13.7	13.4
Middle Eastern countries	59,545	1.4	6,120	0.9	11.8	15.9	17.3
Other	204,397	4.7	27,748	3.9	11.2	16.2	15.8
Region of residence							
Large cities	2,090,922	48.5	298,526	42.2	10.9	15.9	16.4
Medium-sized cities	1,483,061	34.4	265,729	37.6	15.6	18.1	18.6
Small town or rural area	737,755	17.1	143,086	20.2	17.6	19.4	19.3
Hospitalization for chronic lower respiratory disease							
No	4,078,176	94.6	648,169	91.6	12.7	17.2	17.4
Yes	233,562	5.4	59,172	8.4	15.9	21.0	21.1
Hospitalization for alcoholism and related liver disease							
No	4,195,331	97.3	694,395	98.2	12.9	17.5	17.8
Yes	116,407	2.7	12,946	1.8	11.8	14.6	13.8
Hospitalization for obesity							
No	4,235,796	98.2	690,500	97.6	12.8	17.4	17.6
Yes	75,942	1.8	16,841	2.4	17.2	22.2	22.4
Hospitalization for type 2 diabetes							
No	3,985,005	92.4	575,531	81.4	11.7	15.9	15.7
Yes	326,733	7.6	131,810	18.6	31.7	37.7	37.2
Hospitalization for coronary heart disease							
No	3,725,034	86.4	539,821	76.3	12.4	16.8	16.9

	Population		Eye events		Neighborhood deprivation, %		
	n	%	n	%	Low	Moderate	High
Yes	586,704	13.6	167,520	23.7	16.4	21.2	22.1
Hospitalization for stroke							
No	3,903,225	90.5	592,460	83.8	12.7	17.3	17.5
Yes	408,513	9.5	114,881	16.2	15.8	20.5	20.9
Hospitalization for hypertension							
No	3,642,362	84.5	523,160	74.0	12.0	16.4	16.4
Yes	669,376	15.5	184,181	26.0	17.2	22.7	23.8
Hospitalization for dementia							
No	4,193,289	97.3	679,740	96.1	13.0	17.7	17.9
Yes	118,449	2.7	27,601	3.9	13.1	17.9	17.5

Table 2

Multi-level logistic regression models for age-related eye diseases, Sweden

	Men					Women				
	Model 1		Model 2			Model 1		Model 2		
	OR	95% CI	OR	95% CI	P-value	OR	95% CI	OR	95% CI	P-value
Neighborhood deprivation (reference low deprivation)										
Moderate	1.27	1.24–1.30	1.17	1.15–1.20	<0.001	1.40	1.37–1.44	1.23	1.20–1.26	<0.001
High	1.28	1.25–1.32	1.19	1.16–1.23	<0.001	1.52	1.47–1.57	1.25	1.22–1.29	<0.001
Age (reference [AU please include reference group])										
			1.07	1.07–1.07	<0.001			1.07	1.06–1.07	<0.001
Family income (reference high income)										
Middle-high income			0.98	0.97–0.99	0.001			1.01	1.00–1.02	0.230
Middle-low income			0.92	0.91–0.93	<0.001			0.97	0.96–0.98	<0.001
Low income			0.75	0.74–0.76	<0.001			0.81	0.80–0.82	<0.001
Marital status (reference married/cohabiting)										
Never Married, widowed, divorced			0.77	0.77–0.78	<0.001			0.76	0.76–0.77	<0.001
Country of birth (reference Sweden)										
Finland			0.93	0.90–0.95	<0.001			1.03	1.01–1.05	0.004
Western countries			0.99	0.95–1.03	0.617			1.14	1.10–1.17	<0.001
Eastern European countries			0.90	0.86–0.94	<0.001			0.75	0.72–0.77	<0.001
Middle Eastern countries			1.45	1.39–1.51	<0.001			1.18	1.13–1.23	<0.001
Others			1.06	1.03–1.08	<0.001			0.99	0.97–1.01	0.230
Educational attainment (reference >12 years)										
9 years			0.92	0.91–0.93	<0.001			1.10	1.08–1.11	<0.001
10–12 years			0.98	0.97–1.00	0.009			1.15	1.14–1.16	<0.001
Urban/rural status (reference large cities)										
Medium-sized cities			1.23	1.21–1.26	<0.001			1.28	1.25–1.31	<0.001
Small town or rural area			1.39	1.36–1.42	<0.001			1.46	1.43–1.50	<0.001
Comorbidities										
Hospitalization for chronic lower respiratory disease (reference none)			1.29	1.27–1.32	<0.001			1.39	1.37–1.41	<0.001
Hospitalization for alcoholism and related liver disease (reference none)			1.05	1.02–1.07	<0.001			1.02	0.98–1.05	0.368
Hospitalization for obesity (reference none)			0.93	0.91–0.96	<0.001			0.91	0.89–0.94	<0.001

	Men						Women					
	Model 1			Model 2			Model 1			Model 2		
	OR	95% CI		OR	95% CI	P-value	OR	95% CI		OR	95% CI	P-value
Hospitalization for coronary heart disease (reference none)				1.13	1.12–1.14	<0.001				1.13	1.12–1.14	<0.001
Hospitalization for diabetes (reference none)				3.72	3.67–3.76	<0.001				2.77	2.74–2.81	<0.001
Hospitalization for stroke (reference none)				0.98	0.97–0.99	0.001				0.92	0.91–0.93	<0.001
Hospitalization for hypertension (reference none)				1.42	1.41–1.44	<0.001				1.55	1.54–1.57	<0.001
Hospitalization for dementia (reference none)				0.77	0.75–0.78	<0.001				0.59	0.58–0.61	<0.001
Variance (SE)	0.126 (0.003)				0.096 (0.002)		0.172 (0.003)			0.133 (0.003)		
Explained variance, %	6			28			8			29		
Intra-class correlation	0.037				0.028		0.050			0.039		

OR, odds ratio; CI, confidence interval; SE, standard error

Model 1 unadjusted; model 2 adjusted for neighborhood-level deprivation, age, educational attainment, marital status, family income, immigrant status, region of residence, and comorbidities [AU: confirm]

Table 3

Multi-level logistic regression models for macular degeneration, Sweden

	Men				Women					
	Model 1		Model 2		Model 1		Model 2			
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI		
Neighborhood deprivation (reference low deprivation)										
Moderate	1.16	1.12–1.19	1.07	1.04–1.10	<0.001	1.25	1.22–1.29	1.09	1.06–1.12	<0.001
High	1.12	1.07–1.16	1.08	1.03–1.12	<0.001	1.31	1.26–1.36	1.11	1.07–1.15	<0.001
Age (reference [AU please include reference group])										
Family income (reference high income)			1.08	1.07–1.08	<0.001			1.07	1.06–1.07	<0.001
Middle-high income			0.98	0.96–1.01	0.162			0.97	0.95–0.99	0.005
Middle-low income			0.91	0.89–0.93	<0.001			0.93	0.91–0.95	<0.001
Low income			0.73	0.71–0.75	<0.001			0.78	0.76–0.80	<0.001
Marital status (reference married/cohabiting)										
Never married, widowed, divorced			0.73	0.72–0.75	<0.001			0.79	0.77–0.80	<0.001
Country of birth (reference Sweden)										
Finland			1.04	0.98–1.10	0.162			1.10	1.06–1.14	<0.001
Western countries			1.06	0.97–1.15	0.162			1.11	1.05–1.18	0.007
Eastern European countries			0.69	0.62–0.76	<0.001			0.60	0.55–0.66	<0.001
Middle Eastern countries			1.19	1.08–1.31	<0.001			0.74	0.67–0.81	<0.001
Other			1.05	1.01–1.10	0.021			0.99	0.96–1.03	0.764
Educational attainment (reference >12 years)										
9 years			0.86	0.84–0.88	<0.001			1.08	1.05–1.11	<0.001
10–12 years			0.93	0.90–0.96	<0.001			1.11	1.08–1.14	<0.001
Urban/rural status (reference large cities)										
Medium-sized cities			1.17	1.14–1.20	<0.001			1.20	1.18–1.23	<0.001
Small town or rural area			1.26	1.22–1.30	<0.001			1.32	1.28–1.36	<0.001
Comorbidities										
Hospitalization for chronic lower respiratory disease (reference none)			1.34	1.30–1.38	<0.001			1.36	1.33–1.40	<0.001
Hospitalization for alcoholism and related liver disease (reference none)			1.08	1.03–1.14	0.004			1.00	0.93–1.07	0.976
Hospitalization for obesity (reference none)			0.81	0.76–0.87	<0.001			0.87	0.82–0.91	<0.001

	Men			Women		
	Model 1		P-value	Model 1		P-value
	OR	95% CI		OR	95% CI	
Hospitalization for coronary heart disease (reference none)						
	1.15	1.13–1.17	<0.001	1.13	1.11–1.15	<0.001
Hospitalization for diabetes (reference none)						
	1.12	1.09–1.15	<0.001	1.06	1.03–1.08	<0.001
Hospitalization for stroke (reference none)						
	1.00	0.98–1.02	0.920	0.95	0.93–0.97	<0.001
Hospitalization for hypertension (reference none)						
	1.40	1.38–1.43	<0.001	1.45	1.42–1.47	<0.001
Hospitalization for dementia (reference none)						
	0.79	0.76–0.83	<0.001	0.64	0.62–0.66	<0.001
Variance (SE)	0.141 (0.005)			0.161 (0.004)		0.100 (0.003)
Explained variance, %	3	41		6	42	
Intra-class correlation	0.041	0.025		0.047	0.030	

OR, odds ratio; CI, confidence interval; SE, standard error

Model 1 unadjusted; model 2 adjusted for neighborhood-level deprivation, age, educational attainment, marital status, family income, immigrant status, region of residence, and comorbidities [AU: confirm]

Table 4

Multi-level logistic regression models for cataract, Sweden

	Men				Women					
	Model 1		Model 2		Model 1		Model 2			
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI		
Neighborhood deprivation (reference low deprivation)										
Moderate	1.36	1.32–1.39	1.25	1.22–1.29	<0.001	1.49	1.45–1.53	1.30	1.27–1.34	<0.001
High	1.40	1.35–1.45	1.31	1.26–1.35	<0.001	1.65	1.59–1.71	1.36	1.31–1.40	<0.001
Age (reference [AU please include reference group])										
Family income (reference high income)			1.08	1.08–1.08	<0.001			1.07	1.07–1.07	<0.001
Middle-high income			1.01	1.00–1.03	0.110			1.04	1.02–1.05	<0.001
Middle-low income			0.96	0.94–0.97	<0.001			1.03	1.01–1.04	<0.001
Low income			0.77	0.76–0.79	<0.001			0.87	0.86–0.89	<0.001
Marital status (reference married/cohabiting)										
Never married, widowed, divorced			0.76	0.75–0.77	<0.001			0.76	0.75–0.76	<0.001
Country of birth (reference Sweden)										
Finland			1.02	0.99–1.05	0.230			1.11	1.09–1.13	<0.001
Western countries			1.07	1.02–1.12	0.012			1.22	1.18–1.27	<0.001
Eastern European countries			1.02	0.97–1.08	0.424			0.82	0.79–0.86	<0.001
Middle Eastern countries			1.59	1.51–1.67	<0.001			1.32	1.26–1.38	<0.001
Other			1.10	1.07–1.13	<0.001			1.04	1.02–1.07	<0.001
Educational attainment (reference >12 years)										
9 years			0.92	0.91–0.94	<0.001			1.16	1.14–1.18	<0.001
10–12 years			0.98	0.96–0.99	0.005			1.19	1.18–1.21	<0.001
Urban/rural status (reference large cities)										
Medium-sized cities			1.14	1.11–1.16	<0.001			1.19	1.16–1.22	<0.001
Small town or rural area			1.19	1.16–1.22	<0.001			1.30	1.26–1.34	<0.001
Comorbidities										
Hospitalization for chronic lower respiratory disease (reference none)			1.43	1.41–1.46	<0.001			1.48	1.45–1.50	<0.001
Hospitalization for alcoholism and related liver disease (reference none)			1.25	1.21–1.29	<0.001			1.13	1.09–1.17	<0.001
Hospitalization for obesity (reference none)			0.87	0.83–0.90	<0.001			0.86	0.83–0.89	<0.001

	Men			Women		
	Model 1		P-value	Model 1		P-value
	OR	95% CI		OR	95% CI	
Hospitalization for coronary heart disease (reference none)	1.23	1.21–1.24	<0.001	1.15	1.14–1.16	<0.001
Hospitalization for diabetes (reference none)	1.53	1.50–1.55	<0.001	1.39	1.37–1.41	<0.001
Hospitalization for stroke (reference none)	1.00	0.98–1.01	0.549	0.93	0.92–0.94	<0.001
Hospitalization for hypertension (reference none)	1.39	1.37–1.41	<0.001	1.51	1.50–1.53	<0.001
Hospitalization for dementia (reference none)	0.77	0.75–0.79	<0.001	0.63	0.61–0.64	<0.001
Variance (SE)	0.160 (0.004)	0.123 (0.003)		0.200 (0.004)	0.158 (0.003)	
Explained variance, %	7	28		8	27	
Intra-class correlation	0.046	0.036		0.057	0.046	

OR, odds ratio; CI, confidence interval; SE, standard error

Model 1 unadjusted; model 2 adjusted for neighborhood-level deprivation, age, educational attainment, marital status, family income, immigrant status, region of residence, and comorbidities [AU: confirm]

Table 5

Multi-level logistic regression models for diabetes-related eye complications, Sweden

	Men				Women					
	Model 1		Model 2		Model 1		Model 2			
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI		
Neighborhood deprivation (reference low deprivation)										
Moderate	1.37	1.32–1.43	1.22	1.17–1.27	<0.001	1.64	1.56–1.71	1.29	1.23–1.35	<0.001
High	1.60	1.53–1.68	1.36	1.30–1.43	<0.001	2.13	2.02–2.26	1.50	1.42–1.59	<0.001
Age (reference [AU please include reference group])										
Family income (reference high income)			1.00	1.00–1.00	0.317			1.00	1.00–1.00	0.046
Middle-high income			1.09	1.06–1.12	<0.001			1.24	1.19–1.30	<0.001
Middle-low income			1.05	1.01–1.08	0.005			1.37	1.31–1.43	<0.001
Low income			0.92	0.88–0.95	<0.001			1.25	1.20–1.31	<0.001
Marital status (reference married/cohabiting)										
Never married, widowed, divorced			1.04	1.01–1.06	0.004			0.90	0.87–0.92	<0.001
Country of birth (reference Sweden)										
Finland			1.00	0.93–1.06	0.873			0.96	0.90–1.02	0.194
Western countries			1.05	0.94–1.18	0.368			1.12	0.99–1.27	0.171
Eastern European countries			1.54	1.43–1.67	<0.001			1.66	1.53–1.81	<0.001
Middle Eastern countries			1.69	1.56–1.84	<0.001			2.04	1.86–2.24	<0.001
Others			1.24	1.18–1.31	<0.001			1.15	1.08–1.22	<0.001
Educational attainment (reference >12 years)										
9 years			1.18	1.14–1.22	<0.001			1.77	1.70–1.86	<0.001
10–12 years			1.19	1.15–1.23	<0.001			1.60	1.54–1.67	<0.001
Urban/rural status (reference large cities)										
Medium-sized cities			1.29	1.25–1.34	<0.001			1.45	1.39–1.51	<0.001
Small town or rural area			1.46	1.40–1.52	<0.001			1.61	1.53–1.69	<0.001
Comorbidities*										
Hospitalization for chronic lower respiratory disease (reference none)			0.67	0.64–0.71	<0.001			0.69	0.66–0.73	<0.001
Hospitalization for alcoholism and related liver disease (reference none)			0.94	0.89–0.99	0.028			0.94	0.84–1.05	0.271
Hospitalization for obesity (reference none)			2.53	2.38–2.69	<0.001			2.76	2.59–2.94	<0.001

	Men				Women			
	Model 1		Model 2		Model 1		Model 2	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Hospitalization for coronary heart disease (reference none)			1.89	1.84–1.94	<0.001		2.28	2.21–2.35
Hospitalization for stroke (reference none)			1.58	1.54–1.63	<0.001		1.59	1.54–1.65
Hospitalization for hypertension (reference none)			2.66	2.60–2.73	<0.001		2.36	2.29–2.42
Hospitalization for dementia (reference none)			0.99	0.92–1.06	0.764		0.88	0.82–0.94
Variance (SE)	0.169 (0.007)		0.153 (0.007)		0.230 (0.009)		0.183 (0.008)	
Explained variance, %	13		21		22		38	
Intra-class correlation	0.049		0.044		0.065		0.053	

OR, odds ratio; CI, confidence interval; SE, standard error

Model 1 unadjusted; model 2 adjusted for neighborhood-level deprivation, age, educational attainment, marital status, family income, immigrant status, region of residence, and comorbidities [AU: confirm]

* Not adjusted for diabetes.

Table 6

Multi-level logistic regression models for glaucoma, Sweden

	Men				Women					
	Model 1		Model 2		Model 1		Model 2			
	OR	95% CI	OR	95% CI	OR	95% CI	OR	P-value		
Neighborhood deprivation (reference low deprivation)										
Moderate	1.21	1.17–1.25	1.12	1.09–1.16	<0.001	1.29	1.25–1.33	1.14	1.11–1.17	<0.001
High	1.12	1.07–1.17	1.11	1.06–1.15	<0.001	1.25	1.20–1.31	1.12	1.08–1.17	<0.001
Age (reference [AU please include reference group])										
Family income (reference high income)			1.06	1.06–1.06	<0.001			1.05	1.05–1.05	<0.001
Middle-high income			0.95	0.93–0.98	<0.001			0.99	0.97–1.01	0.194
Middle-low income			0.89	0.87–0.91	<0.001			0.91	0.89–0.93	<0.001
Low income			0.76	0.74–0.78	<0.001			0.80	0.78–0.82	<0.001
Marital status (reference married/cohabiting)										
Never married, widowed, divorced			0.78	0.76–0.79	<0.001			0.80	0.79–0.82	<0.001
Country of birth (reference Sweden)										
Finland			0.70	0.66–0.75	<0.001			0.80	0.76–0.83	<0.001
Western countries			0.82	0.75–0.90	<0.001			0.89	0.83–0.96	0.001
Eastern European countries			0.57	0.51–0.63	<0.001			0.00	0.00–0.00	<0.001
Middle Eastern countries			0.80	0.72–0.88	<0.001			0.00	0.00–0.00	<0.001
Other			0.85	0.81–0.89	<0.001			0.00	0.00–0.00	<0.001
Educational attainment (reference >12 years)										
9 years			0.89	0.87–0.91	<0.001			1.05	1.03–1.08	<0.001
10–12 years			0.98	0.95–1.00	0.089			1.10	1.08–1.12	<0.001
Urban/rural status (reference large cities)										
Medium-sized cities			1.33	1.30–1.37	<0.001			1.34	1.30–1.37	<0.001
Small town or rural area			1.75	1.69–1.81	<0.001			1.70	1.65–1.76	<0.001
Comorbidities										
Hospitalization for chronic lower respiratory disease (reference none)			1.07	1.04–1.11	0.001			1.11	1.08–1.14	<0.001
Hospitalization for alcoholism and related liver disease (reference none)			0.89	0.84–0.93	<0.001			0.86	0.80–0.92	<0.001
Hospitalization for obesity (reference none)			0.90	0.84–0.96	0.001			0.89	0.85–0.94	<0.001

	Men						Women					
	Model 1			Model 2			Model 1			Model 2		
	OR	95% CI		OR	95% CI	P-value	OR	95% CI		OR	95% CI	P-value
Hospitalization for coronary heart disease (reference none)				0.91	0.90–0.93	<0.001				0.94	0.92–0.96	<0.001
Hospitalization for diabetes (reference none)				1.18	1.15–1.21	<0.001				1.08	1.05–1.10	<0.001
Hospitalization for stroke (reference none)				0.91	0.89–0.93	<0.001				0.89	0.88–0.91	<0.001
Hospitalization for hypertension (reference none)				1.21	1.18–1.23	<0.001				1.27	1.25–1.29	<0.001
Hospitalization for dementia (reference none)				0.87	0.83–0.91	<0.001				0.73	0.71–0.76	<0.001
Variance (SE)	0.195 (0.005)				0.129 (0.004)		0.222 (0.005)			0.162 (0.004)		
Explained variance, %	3			36			3			29		
Intra-class correlation	0.056			0.038			0.063			0.047		

OR, odds ratio; CI, confidence interval; SE, standard error

Model 1 unadjusted; model 2 adjusted for neighborhood-level deprivation, age, educational attainment, marital status, family income, immigrant status, region of residence, and comorbidities [AU: confirm]