



Contents lists available at ScienceDirect

Archives of Gerontology and Geriatrics

journal homepage: www.elsevier.com/locate/archger

Dementia in immigrant groups: A cohort study of all adults 45 years of age and older in Sweden



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ARTICLE INFO

Keywords:

Dementia

Gender

First generation immigrants

Neighbourhood

Socioeconomic status

ABSTRACT

Objective: To study the association between country of birth and incident dementia in several immigrant groups in Sweden.

Methods: The study population included all adults ($n = 3,286,624$) aged 45 years and older in Sweden. Dementia was defined as having at least one registered diagnosis of dementia in the National Patient Register. The incidence of dementia in different immigrant groups, using Swedish-born as referents, was assessed by Cox regression, expressed in hazard ratios (HRs) and 95% confidence intervals (CI). All models were stratified by sex and adjusted for age, geographical residence in Sweden, educational level, marital status, and neighbourhood socioeconomic status.

Results: A total of 136,713 individuals had a registered dementia event, i.e. 4.2%; 3.6% among men and 4.9% among women. After adjusting for confounders, in general, there was a lower incidence of dementia among both male immigrants (HR 0.85, 0.83–0.88) and female immigrants (HR 0.93, 0.91–0.95) compared to their Swedish-born counterparts. Among immigrant groups, a higher incidence (HR, 95%CI) of dementia was observed among men from Finland (1.14, 1.08–1.20), Bosnia (1.61, 1.18–2.20), Estonia (1.25, 1.10–1.43) and Russia (1.37, 1.12–1.69), and women from Finland (1.20, 1.15–1.24) and Norway (1.14, 1.07–1.22).

Conclusions: Risk of dementia was lower in immigrants in general compared to the Swedish-born population; however there were substantial differences among immigrant groups in risk of dementia. Developing dementia in a new country with a different language could cause problems for both patients and the health care staff.

1. Introduction

Dementia is of increasing importance in the world (Livingston et al., 2017), with varying prevalence in different regions (Rizzi, Rosset, & Roriz-Cruz, 2014). However, these differences could partly be due to differences in methodology among studies, including diagnostic criteria, and also to differences of mean age in the populations. Dementia is common especially among the elderly, but the age-specific prevalence of dementia seem to have decreased over time, both in Sweden (Skoog et al., 2017), the UK (Ahmadi-Abhari et al., 2017), and the US (Langa et al., 2017), even if the number of subjects with dementia increases owing to an aging population. Globally, the trend is unclear,

and dementia seems to increase in some parts of the world such as East Asia (Prince et al., 2016).

Migration worldwide is increasing, and it is estimated that foreign-born individuals account for approximately 17% of the registered Swedish population (data from Statistics Sweden) (Statistics Sweden, 2016). In general, the health of immigrants often tends to be better than that of the native population upon arrival to the new country; and the migrating populations seem to be in better health than people remaining in the country of origin, i.e. the “healthy migrant effect”. However, the health of immigrants tends to decline as time goes by in their new home country (Antecol & Bedard, 2006; De Maio & Kemp, 2010).

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<https://doi.org/10.1016/j.archger.2019.03.003>

Received 20 November 2018; Received in revised form 4 March 2019; Accepted 5 March 2019

Available online 06 March 2019

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Among immigration studies in Europe, African-Caribbean immigrants are found to exert a higher risk of dementia in the UK, and also at younger ages than the UK-born (Adelman, Blanchard, Rait, Leavey, & Livingston, 2011). On the other hand, a Norwegian study found a lower prevalence of dementia in immigrants compared to the Norwegian-born population (Diaz, Kumar, & Engedal, 2015). No Swedish study on the topic has been published. Considering that studies on the topic are scarce, often with conflicting results and examining prevalence rather than incidence, further studies on this topic are warranted.

Therefore, the aim of this study was to describe the risk of being diagnosed with dementia among first-generation immigrants in Sweden as compared to Swedish-born individuals as well as to compare the specific risk of being diagnosed with dementia among different immigrant groups.

2. Methods

2.1. Design

The registers used in the present study were the Total Population Register and the National Patient Register. Subjects aged 45 years of age and older were included in the study. The follow-up period ran from January 1, 1998 until hospitalisation/out-patient treatment of dementia, death, emigration or the end of the study period on December 31, 2012, whichever came first. Out-patient diagnoses were included nationwide from 2001 and onwards from specialist care only, not primary health care.

2.2. Study population

As dementia in young individuals is rare and has a different risk factor pattern than among older individuals, the study included the whole Swedish population aged 45 years and older. Patients with a dementia diagnosis prior to January 1, 1998 were excluded in order to “wash-out” those with pre-existing disease. Country of birth was registered and the present study was based on analyses of 10 regions (Nordic countries, Southern Europe, Western Europe, Eastern Europe, Baltic countries, Central Europe, Africa, North America, Latin America and Asia) and separate analyses from 27 countries (Supplementary Table 1). Countries with less than 10 observed cases of dementia were not analysed separately. First-generation immigrants were defined as those born outside Sweden and were compared to Swedish-born individuals.

2.3. Outcome variable

Dementia incidence, i.e., patients with diagnosed dementia were identified by the presence of the ICD-10 code (10th version of the World Health Organization's International Classification of Diseases) for dementia (with the following subgroups: F00 Alzheimer's disease, F01 Vascular dementia, F02 Other dementia diseases, F03 Unspecified dementia, F10.7A Alcohol-related dementia, G30 Alzheimer, and G31.8A Degenerative changes at Lewy-body dementia) in the National Patient Register. Dementia diagnosed before 1998, i.e. during the years 1987–1997 (according to ICD-9 1987–1996 and ICD-10 1997) were excluded. Time was calculated from January 1, 1998 until hospitalisation/out-patient treatment of dementia according to the ICD-10 codes above (among individuals at an age of diagnosis of 45 years or older), death, emigration or the end of the study period on December 31, 2012, whichever came first.

2.4. Exposure

Immigrant status. “The date of immigration” was taken as the date of the residence permit, i.e. when the migrants got their Swedish personal identification number.

2.5. Confounding variables: demography and socioeconomic variables

Socio-demographic variables included age (used as a continuous variable), sex, and educational attainment (≤ 9 years (partial or complete compulsory schooling), 10–12 years (partial or complete secondary schooling) and > 12 years (attendance at college and/or university)), and marital status (married or not). Geographic region of residence was included to adjust for possible regional differences in hospital admissions and was categorised as large cities, southern Sweden and northern Sweden. Large cities were defined as municipalities with a population of $> 200,000$ and comprised the three largest cities in Sweden: Stockholm, Gothenburg and Malmö. Neighbourhood socioeconomic status was also included in the analyses. Neighbourhoods were derived from Small Area Market Statistics (SAMS). The index was categorised into three groups: more than one standard deviation (SD) below the mean (high SES or low-deprivation level), more than one SD above the mean (low SES or high-deprivation level), and within one SD of the mean (middle SES or middle-deprivation level), with neighbourhood status classified as high, middle or low SES (corresponding to the categories low, middle and high-deprivation in the index).

2.6. Confounding variables: co-morbidities

We identified co-morbidities according to ICD-10 for the following diagnoses: hypertension I10-I19, coronary heart disease (CHD) I20-I25, congestive heart failure I50, atrial fibrillation I48, stroke I60-I69, obesity E65-E68, diabetes E10-E14, chronic obstructive pulmonary disease (COPD) J40-J47, depression F32-F33, and alcoholism and related disorders F10 and K70.

2.7. Statistical analysis

The number of dementia cases was identified for the first-generation immigrants and across baseline subject characteristics. Cox regression analysis was used to estimate the risk of incident dementia in different immigrant groups compared to the Swedish-born population. All analyses were stratified by sex with regard to the different age profiles and rate of dementia. Three models were used in the analyses: Model 1 was adjusted for age and region of residence; Model 2 was adjusted for age, region of residence, educational level, marital status and neighbourhood SES; Model 3 was also adjusted for co-morbidities. We also performed additional analyses, firstly by categorizing into individuals aged 45–74 years of age or 75 years of age and above, and secondly also into regions with health risky alcohol intake on population level (Popova, Rehm, Patra, & Zatonski, 2007), i.e. Baltic countries, Central Europe, Romania and Russia, or known low levels of alcohol intake, i.e. countries in the Middle East region (Turkey, Lebanon, Iran, Iraq). A third additional analysis was performed, classifying regions and countries into northern regions (Nordic countries, Western European countries, Baltic countries, Central European countries, Russia, North America, and the following countries in Eastern Europe: Bosnia, Romania, Bulgaria, and other EE countries except Yugoslavia and Croatia) or southern regions (Southern European countries, Yugoslavia and Croatia, Africa, Asia and Latin America). As a sensitivity analysis to this north-south study immigrants moving to Sweden within the last 5 years of follow-up were excluded.

The adjusted population attributable fraction (PAF), or population attributable risk (PAR), was estimated in percent for risk factors as prevalence (%) among cases multiplied by $HR-1/HR$ (Miettinen, 1974), using adjusted HRs for the different factors. This method has also been used in other studies of dementia (Hazar, Seddigh, Rampisheh, & Nojomi, 2016). PAF is useful in order to compare the impact of different risk factors on the incidence of the outcome, in this case dementia.

The study was approved by the regional ethics boards at Karolinska Institutet and Lund University.

Table 1
Population and number of cases of dementia events categorized by sex.

| | Men | | | | Women | | | |
|---|---------------|------|------------|------|---------------|------|------------|------|
| | Population No | % | Events No. | % | Population No | % | Events No. | % |
| Total population | 1556768 | | 56164 | | 1729856 | | 80549 | |
| Total events | | | | | | | | |
| Alzheimer's disease | | | 16985 | 30.2 | | | 27628 | 34.3 |
| Vascular dementia | | | 12969 | 23.1 | | | 13438 | 16.7 |
| Other dementia diseases | | | 26210 | 46.7 | | | 39483 | 49.0 |
| Immigrant status | | | | | | | | |
| Sweden | 1335195 | 85.8 | 51703 | 92.1 | 1512745 | 87.4 | 73942 | 91.8 |
| Other countries | 221573 | 14.2 | 4461 | 7.9 | 217111 | 12.6 | 6607 | 8.2 |
| Birth year | | | | | | | | |
| -1909 | 32508 | 2.1 | 838 | 1.5 | 41231 | 2.4 | 1901 | 2.4 |
| 1910–19 | 136281 | 8.8 | 11938 | 21.3 | 204687 | 11.8 | 22284 | 27.7 |
| 1920–29 | 280856 | 18.0 | 25428 | 45.3 | 343860 | 19.9 | 37232 | 46.2 |
| 1930–39 | 356573 | 22.9 | 13456 | 24.0 | 376368 | 21.8 | 14699 | 18.2 |
| 1940–49 | 544846 | 35.0 | 4045 | 7.2 | 549176 | 31.7 | 3941 | 4.9 |
| 1950– | 205704 | 13.2 | 459 | 0.8 | 211923 | 12.3 | 489 | 0.6 |
| Educational level | | | | | | | | |
| ≤ 9 | 704887 | 45.3 | 29578 | 52.7 | 842818 | 48.7 | 51913 | 64.4 |
| 10–12 | 329088 | 21.1 | 10766 | 19.2 | 493603 | 28.5 | 19179 | 23.8 |
| > 12 | 522793 | 33.6 | 15820 | 28.2 | 393435 | 22.7 | 9457 | 11.7 |
| Region of residence | | | | | | | | |
| Large cities | 511678 | 32.9 | 21882 | 39.0 | 583089 | 33.7 | 33466 | 41.5 |
| Southern Sweden | 680953 | 43.7 | 23535 | 41.9 | 774134 | 44.8 | 32223 | 40.0 |
| Northern Sweden | 364137 | 23.4 | 10747 | 19.1 | 372633 | 21.5 | 14860 | 18.4 |
| Marital status | | | | | | | | |
| Married | 1194447 | 76.7 | 44051 | 78.4 | 1461831 | 84.5 | 59158 | 73.4 |
| Unmarried | 362321 | 23.3 | 12113 | 21.6 | 268025 | 15.5 | 21391 | 26.6 |
| Neighbourhood deprivation | | | | | | | | |
| Low | 238133 | 15.3 | 8040 | 14.3 | 254771 | 14.7 | 10343 | 12.8 |
| Middle | 766991 | 49.3 | 28747 | 51.2 | 889579 | 51.4 | 40972 | 50.9 |
| High | 169510 | 10.9 | 6322 | 11.3 | 197936 | 11.4 | 9098 | 11.3 |
| Unknown | 382134 | 24.5 | 13055 | 23.2 | 387570 | 22.4 | 20136 | 25.0 |
| Hospital diagnosis of hypertension | 310322 | 19.9 | 12191 | 21.7 | 358281 | 20.7 | 18184 | 22.6 |
| Hospital diagnosis of CHD | 289293 | 18.6 | 13676 | 24.4 | 212624 | 12.3 | 13702 | 17.0 |
| Hospital diagnosis of CHF | 161637 | 10.4 | 9219 | 16.4 | 153514 | 8.9 | 11036 | 13.7 |
| Hospitalization of atrial fibrillation | 163485 | 10.5 | 9306 | 16.6 | 155577 | 9.0 | 11174 | 13.9 |
| Hospital diagnosis of stroke | 175792 | 11.3 | 14591 | 26.0 | 174213 | 10.1 | 15737 | 19.5 |
| Hospital diagnosis of obesity | 10760 | 0.7 | 149 | 0.3 | 16659 | 1.0 | 204 | 0.3 |
| Hospital diagnosis of diabetes | 158432 | 10.2 | 7640 | 13.6 | 136999 | 7.9 | 8217 | 10.2 |
| Hospital diagnosis of COPD | 94677 | 6.1 | 4021 | 7.2 | 113907 | 6.6 | 5015 | 6.2 |
| Hospital diagnosis of depression | 37645 | 2.4 | 3961 | 7.1 | 61043 | 3.5 | 6768 | 8.4 |
| Hospital diagnosis of alcoholism | 48018 | 3.1 | 2958 | 5.3 | 18991 | 1.1 | 1289 | 1.6 |

3. Results

Characteristics of the study population are presented in Table 1, with 56,164 registered cases among men (3.6%) and 80,549 among women (4.7%), in total 4.2%. Among men, dementia was recorded in 2.0% of foreign-born vs 3.9% of Swedish-born, and, among women, in 3.0% of foreign-born vs 4.9% of Swedish-born. Rates of cardiovascular diseases were generally high, and even higher among individuals with dementia for stroke, atrial fibrillation, and congestive heart failure.

Tables 2 and 3 show HRs for dementia among men and women, respectively, by region or country of origin. Among men, the HRs in full models for dementia were higher in men from Finland, Bosnia, Iraq, Estonia and Russia. Among women, the HRs for dementia were higher among individuals from Finland and Norway. Lower HRs were found in many immigrant groups among both men and women, i.e., among men from Denmark, Iceland, Southern Europe, Western Europe, Eastern Europe, Central Europe, Africa, Latin-America, and Asia (except Iraq) and among women from Denmark, Iceland, Southern Europe, Western Europe (except the Netherlands), East Europe, Central Europe, Africa, Latin-America, and Asia. When categorizing into age-groups there were only minor differences between the age groups 45–74 years and ≥75 years, with the fully adjusted HRs (95% CI) in immigrant men 0.72 (95% CI 0.69–0.75) and 0.71 (95% CI 0.67–0.76), respectively, and in immigrant women 0.82 (95% CI 0.79–0.85) and 0.85 (95% CI

0.82–0.89), respectively. For high-risk alcohol regions the HRs were in men 1.00 (95% CI 0.93–1.08) and in women 0.90 (95% CI 0.83–0.96), and for low-risk alcohol regions in men 0.85 (95% CI 0.74–0.97) and in women 0.70 (95% CI 0.58–0.85).

Further categorization of the study population into Swedish- and foreign-born men and women was also performed (Supplementary Tables 1a and 1b). We also estimated PAFs for Swedish- and foreign-born men and women, respectively (Tables 4 and 5), also categorized according to age-group. The total percentage of co-morbidities positively contributing to incident dementia were for Swedish-born men 23.5%, foreign-born men 34.4%, Swedish-born women 14.7% and foreign-born women 28.2%. The highest PAF values in men were shown in Swedish-born for stroke (12.7%) and depression (4.4%); and in foreign-born for stroke (14.9%), AF (6.6%), depression (6.0%), alcoholism (5.7%) and diabetes (4.8%). The corresponding highest PAF values in women were shown in Swedish-born for stroke (5.9%) and depression (5.1%); and in foreign-born for depression (9.0%), alcoholism (8.7%), and diabetes (5.4%). Some co-morbidities showed negative PAFs, i.e. especially hypertension. When looking at age-categorized values, the PAFs for the age-groups differed (Tables 4 and 5), with higher HRs among younger men for stroke, depression and alcohol-related diagnoses, and also among younger women for stroke and depression. HRs for stroke was highest among foreign-born men 45–74 years with adjusted PAF 16.0, and lowest among Swedish-born women ≥75 years

Table 2
HR of dementia in male immigrants by region and country of origin.

| | Model 1 | | | Model 2 | | | Model 3 | | | Model 4 | | |
|-------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| | HR | 95% CI | | HR | 95% CI | | HR | 95% CI | | HR | 95% CI | |
| Sweden | 1 | | | 1 | | | 1 | | | 1 | | |
| All immigrants | 0.75 | 0.73 | 0.77 | 0.75 | 0.73 | 0.77 | 0.84 | 0.81 | 0.87 | 0.85 | 0.83 | 0.88 |
| Nordic countries | 0.92 | 0.88 | 0.96 | 0.92 | 0.88 | 0.96 | 1.02 | 0.98 | 1.07 | 1.02 | 0.98 | 1.06 |
| Denmark | 0.72 | 0.65 | 0.80 | 0.72 | 0.65 | 0.79 | 0.71 | 0.64 | 0.79 | 0.73 | 0.66 | 0.80 |
| Finland | 0.98 | 0.93 | 1.03 | 0.98 | 0.93 | 1.03 | 1.16 | 1.10 | 1.22 | 1.14 | 1.08 | 1.20 |
| Iceland | 0.27 | 0.12 | 0.60 | 0.28 | 0.13 | 0.62 | 0.33 | 0.15 | 0.73 | 0.34 | 0.15 | 0.76 |
| Norway | 1.01 | 0.91 | 1.11 | 1.01 | 0.91 | 1.11 | 1.05 | 0.95 | 1.16 | 1.05 | 0.95 | 1.16 |
| Southern Europe | 0.37 | 0.31 | 0.43 | 0.37 | 0.31 | 0.43 | 0.44 | 0.38 | 0.52 | 0.47 | 0.40 | 0.56 |
| France | 0.55 | 0.36 | 0.86 | 0.55 | 0.36 | 0.86 | 0.67 | 0.43 | 1.04 | 0.68 | 0.44 | 1.05 |
| Greece | 0.21 | 0.15 | 0.30 | 0.22 | 0.16 | 0.31 | 0.28 | 0.20 | 0.39 | 0.30 | 0.22 | 0.43 |
| Italy | 0.46 | 0.36 | 0.59 | 0.46 | 0.36 | 0.59 | 0.55 | 0.43 | 0.70 | 0.58 | 0.45 | 0.74 |
| Spain | 0.40 | 0.26 | 0.61 | 0.40 | 0.26 | 0.61 | 0.50 | 0.32 | 0.76 | 0.51 | 0.33 | 0.78 |
| Other SE countries | 0.43 | 0.24 | 0.75 | 0.43 | 0.24 | 0.75 | 0.44 | 0.25 | 0.77 | 0.47 | 0.26 | 0.82 |
| Western Europe | 0.68 | 0.62 | 0.74 | 0.68 | 0.62 | 0.74 | 0.74 | 0.68 | 0.81 | 0.76 | 0.70 | 0.83 |
| The Netherlands | 0.84 | 0.63 | 1.13 | 0.84 | 0.62 | 1.12 | 0.91 | 0.67 | 1.22 | 0.94 | 0.70 | 1.27 |
| UK and Ireland | 0.52 | 0.39 | 0.68 | 0.52 | 0.40 | 0.69 | 0.63 | 0.47 | 0.83 | 0.66 | 0.50 | 0.87 |
| Germany | 0.73 | 0.65 | 0.81 | 0.72 | 0.65 | 0.81 | 0.77 | 0.69 | 0.86 | 0.78 | 0.70 | 0.87 |
| Austria | 0.60 | 0.47 | 0.77 | 0.59 | 0.46 | 0.77 | 0.66 | 0.51 | 0.86 | 0.68 | 0.52 | 0.87 |
| Other WE countries | 0.54 | 0.35 | 0.83 | 0.54 | 0.35 | 0.84 | 0.63 | 0.41 | 0.98 | 0.66 | 0.42 | 1.02 |
| Eastern Europe | 0.54 | 0.48 | 0.62 | 0.54 | 0.48 | 0.62 | 0.56 | 0.49 | 0.63 | 0.58 | 0.51 | 0.65 |
| Bosnia | 1.20 | 0.88 | 1.64 | 1.24 | 0.91 | 1.69 | 1.77 | 1.30 | 2.41 | 1.61 | 1.18 | 2.20 |
| Yugoslavia | 0.49 | 0.42 | 0.58 | 0.49 | 0.42 | 0.57 | 0.50 | 0.43 | 0.58 | 0.51 | 0.44 | 0.60 |
| Croatia | 0.48 | 0.28 | 0.82 | 0.48 | 0.28 | 0.82 | 0.44 | 0.26 | 0.76 | 0.48 | 0.28 | 0.83 |
| Romania | 0.52 | 0.34 | 0.79 | 0.52 | 0.34 | 0.79 | 0.54 | 0.36 | 0.82 | 0.57 | 0.38 | 0.87 |
| Bulgaria | 0.55 | 0.28 | 1.10 | 0.55 | 0.28 | 1.10 | 0.60 | 0.30 | 1.21 | 0.65 | 0.33 | 1.30 |
| Other EE countries | 0.36 | 0.13 | 0.95 | 0.36 | 0.14 | 0.97 | 0.31 | 0.12 | 0.83 | 0.36 | 0.13 | 0.95 |
| Baltic countries | 1.12 | 0.99 | 1.26 | 1.12 | 0.99 | 1.26 | 1.20 | 1.06 | 1.36 | 1.20 | 1.06 | 1.36 |
| Estonia | 1.16 | 1.01 | 1.32 | 1.16 | 1.02 | 1.32 | 1.26 | 1.10 | 1.43 | 1.25 | 1.10 | 1.43 |
| Latvia | 0.90 | 0.64 | 1.27 | 0.89 | 0.63 | 1.25 | 0.93 | 0.66 | 1.31 | 0.96 | 0.68 | 1.35 |
| Central Europe | 0.85 | 0.77 | 0.95 | 0.84 | 0.76 | 0.94 | 0.86 | 0.78 | 0.96 | 0.88 | 0.79 | 0.97 |
| Poland | 0.93 | 0.79 | 1.08 | 0.92 | 0.79 | 1.08 | 0.94 | 0.81 | 1.11 | 0.94 | 0.80 | 1.10 |
| Other CE countries | 0.67 | 0.52 | 0.86 | 0.67 | 0.52 | 0.86 | 0.68 | 0.53 | 0.88 | 0.71 | 0.55 | 0.91 |
| Hungary | 0.88 | 0.75 | 1.03 | 0.87 | 0.74 | 1.02 | 0.87 | 0.74 | 1.03 | 0.90 | 0.77 | 1.06 |
| Africa | 0.58 | 0.45 | 0.75 | 0.56 | 0.44 | 0.73 | 0.70 | 0.54 | 0.91 | 0.72 | 0.56 | 0.93 |
| Northern America | 0.98 | 0.82 | 1.16 | 0.99 | 0.83 | 1.17 | 1.07 | 0.90 | 1.28 | 1.08 | 0.91 | 1.28 |
| Latin America | 0.38 | 0.29 | 0.50 | 0.37 | 0.28 | 0.49 | 0.45 | 0.34 | 0.60 | 0.48 | 0.36 | 0.63 |
| Chile | 0.49 | 0.35 | 0.68 | 0.47 | 0.34 | 0.65 | 0.59 | 0.43 | 0.81 | 0.62 | 0.45 | 0.86 |
| South America | 0.23 | 0.13 | 0.40 | 0.22 | 0.12 | 0.39 | 0.26 | 0.15 | 0.46 | 0.28 | 0.16 | 0.49 |
| Asia | 0.61 | 0.55 | 0.69 | 0.63 | 0.56 | 0.71 | 0.74 | 0.66 | 0.83 | 0.76 | 0.68 | 0.86 |
| Turkey | 0.74 | 0.60 | 0.91 | 0.77 | 0.62 | 0.94 | 0.94 | 0.77 | 1.16 | 0.97 | 0.79 | 1.20 |
| Lebanon | 0.23 | 0.11 | 0.52 | 0.24 | 0.11 | 0.53 | 0.29 | 0.13 | 0.64 | 0.29 | 0.13 | 0.65 |
| Iran | 0.61 | 0.47 | 0.79 | 0.62 | 0.48 | 0.80 | 0.68 | 0.53 | 0.88 | 0.69 | 0.53 | 0.89 |
| Iraq | 1.04 | 0.78 | 1.38 | 1.05 | 0.79 | 1.40 | 1.34 | 1.01 | 1.78 | 1.32 | 0.99 | 1.76 |
| Other Asia countries | 0.47 | 0.37 | 0.58 | 0.47 | 0.38 | 0.60 | 0.56 | 0.44 | 0.70 | 0.58 | 0.46 | 0.73 |
| Russia | 1.35 | 1.10 | 1.66 | 1.34 | 1.09 | 1.64 | 1.39 | 1.14 | 1.71 | 1.37 | 1.12 | 1.69 |

Model 1: adjusted for age and region of residence in Sweden; model 2: + educational level and marital status; model 3: + neighborhood deprivation; model 4: + comorbidities; Bold values statistically significant.

with 1.3.

For the high- and low-alcohol risk regions the PAFs showed great variation (Supplementary Table 2). In the high-alcohol risk region fully adjusted PAF (95% CI) in men for stroke was 12.5 (9.6–14.9), and in women 6.3 (3.5–8.6), and in the low-alcohol risk region in men 19.1 (15.2–21.8) and in women 8.5 (1.5–12.6); for diabetes the fully adjusted PAF in the high-alcohol risk region was in men 4.3 (1.6–6.4) and in women 3.1 (0.8–5.0), and in the low-alcohol risk region in men 14.9 (8.3–19.7) and in women 19.2 (10.1–25.2); for depression the fully adjusted PAF in the high-alcohol risk region was in men 3.8 (2.9–4.5) and in women 4.7 (3.5–5.6), and in the low-alcohol risk region in men 12.6 (11.1–13.5) and in women 13.3 (11.1–14.6).

We also found a clear gradient in Northern vs Southern regions (Supplementary Table 3), with HRs for male immigrants 0.97 (95% CI 0.94–1.01) and 0.59 (0.54–0.63), respectively, and for female immigrants 1.02 (95% CI 0.99–1.05) and 0.58 (95% CI 0.54–0.64). The sensitivity analysis showed very similar results when excluding immigrants moving to Sweden the last 5 years of the study period.

4. Discussion

In this study of 3,286,624 individuals in Sweden, we explored the risk of dementia among different immigrant groups compared to Swedish-born and observed that the risk of incident dementia was, in general, lower in male immigrants compared to Swedish-born men, while no substantial difference was noted between female immigrants and Swedish-born women. However, a higher incidence of dementia was found among men from Finland, Bosnia, Estonia, Iraq and Russia, and among women from Finland and Norway, compared to their Swedish-born counterparts.

Our results are in agreement with a Norwegian study, finding a lower prevalence of dementia in immigrants than in the Norwegian-born population (Diaz et al., 2015). However, we also found an increased risk of incident dementia in some specific groups, mostly in immigrants of European descent, i.e., from some Nordic countries as well as from countries from the Eastern part of Europe. We also found an increased risk among immigrants from two war-torn countries, i.e. Bosnia and Iraq, countries with the highest rate of immigrants

Table 3
HR of dementia in female immigrants by region and country of origin.

| | Model 1 | | | Model 2 | | | Model 3 | | | Model 4 | | |
|-------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| | HR | 95% CI | | HR | 95% CI | | HR | 95% CI | | HR | 95% CI | |
| Sweden | 1 | | | 1 | | | 1 | | | 1 | | |
| All immigrants | 0.88 | 0.85 | 0.90 | 0.88 | 0.86 | 0.90 | 0.92 | 0.90 | 0.95 | 0.93 | 0.91 | 0.95 |
| Nordic countries | 1.07 | 1.03 | 1.10 | 1.06 | 1.03 | 1.09 | 1.10 | 1.07 | 1.14 | 1.11 | 1.08 | 1.15 |
| Denmark | 0.76 | 0.69 | 0.83 | 0.76 | 0.69 | 0.83 | 0.76 | 0.70 | 0.83 | 0.77 | 0.70 | 0.84 |
| Finland | 1.12 | 1.08 | 1.17 | 1.12 | 1.08 | 1.16 | 1.18 | 1.14 | 1.23 | 1.20 | 1.15 | 1.24 |
| Iceland | 0.25 | 0.11 | 0.56 | 0.25 | 0.11 | 0.56 | 0.28 | 0.13 | 0.62 | 0.27 | 0.12 | 0.61 |
| Norway | 1.14 | 1.07 | 1.21 | 1.13 | 1.06 | 1.20 | 1.14 | 1.07 | 1.22 | 1.14 | 1.07 | 1.22 |
| Southern Europe | 0.53 | 0.46 | 0.62 | 0.54 | 0.46 | 0.63 | 0.59 | 0.50 | 0.69 | 0.60 | 0.51 | 0.70 |
| France | 0.78 | 0.55 | 1.10 | 0.81 | 0.57 | 1.14 | 0.88 | 0.62 | 1.24 | 0.88 | 0.62 | 1.24 |
| Greece | 0.32 | 0.23 | 0.45 | 0.32 | 0.23 | 0.44 | 0.35 | 0.25 | 0.49 | 0.37 | 0.26 | 0.51 |
| Italy | 0.60 | 0.46 | 0.77 | 0.60 | 0.47 | 0.77 | 0.66 | 0.51 | 0.85 | 0.66 | 0.51 | 0.84 |
| Spain | 0.72 | 0.49 | 1.06 | 0.72 | 0.49 | 1.05 | 0.79 | 0.54 | 1.16 | 0.79 | 0.54 | 1.16 |
| Other SE countries | 0.55 | 0.29 | 1.02 | 0.55 | 0.29 | 1.01 | 0.57 | 0.31 | 1.06 | 0.58 | 0.31 | 1.08 |
| Western Europe | 0.75 | 0.70 | 0.81 | 0.76 | 0.71 | 0.82 | 0.79 | 0.73 | 0.85 | 0.80 | 0.74 | 0.86 |
| The Netherlands | 0.99 | 0.74 | 1.34 | 1.02 | 0.76 | 1.37 | 1.08 | 0.80 | 1.45 | 1.06 | 0.79 | 1.43 |
| UK and Ireland | 0.49 | 0.37 | 0.66 | 0.51 | 0.38 | 0.67 | 0.54 | 0.41 | 0.72 | 0.55 | 0.41 | 0.73 |
| Germany | 0.78 | 0.72 | 0.85 | 0.79 | 0.73 | 0.86 | 0.81 | 0.75 | 0.88 | 0.82 | 0.76 | 0.89 |
| Austria | 0.68 | 0.53 | 0.88 | 0.69 | 0.54 | 0.89 | 0.72 | 0.56 | 0.92 | 0.73 | 0.57 | 0.94 |
| Other WE countries | 0.71 | 0.48 | 1.06 | 0.74 | 0.50 | 1.09 | 0.79 | 0.54 | 1.17 | 0.82 | 0.55 | 1.21 |
| Eastern Europe | 0.59 | 0.52 | 0.68 | 0.60 | 0.52 | 0.68 | 0.61 | 0.53 | 0.70 | 0.61 | 0.53 | 0.70 |
| Bosnia | 0.72 | 0.46 | 1.14 | 0.73 | 0.47 | 1.15 | 0.87 | 0.56 | 1.37 | 0.85 | 0.54 | 1.34 |
| Yugoslavia | 0.54 | 0.45 | 0.64 | 0.54 | 0.45 | 0.64 | 0.55 | 0.46 | 0.65 | 0.55 | 0.46 | 0.65 |
| Croatia | 0.28 | 0.12 | 0.66 | 0.28 | 0.12 | 0.67 | 0.27 | 0.11 | 0.65 | 0.27 | 0.11 | 0.65 |
| Romania | 0.87 | 0.61 | 1.23 | 0.90 | 0.64 | 1.27 | 0.94 | 0.66 | 1.32 | 0.90 | 0.64 | 1.28 |
| Bulgaria | 0.81 | 0.40 | 1.62 | 0.86 | 0.43 | 1.72 | 0.92 | 0.46 | 1.83 | 0.92 | 0.46 | 1.83 |
| Other EE countries | 1.22 | 0.58 | 2.56 | 1.22 | 0.58 | 2.55 | 1.17 | 0.56 | 2.46 | 1.14 | 0.55 | 2.40 |
| Baltic countries | 0.85 | 0.76 | 0.96 | 0.88 | 0.78 | 0.99 | 0.92 | 0.82 | 1.03 | 0.93 | 0.83 | 1.04 |
| Estonia | 0.84 | 0.74 | 0.95 | 0.86 | 0.76 | 0.97 | 0.90 | 0.79 | 1.01 | 0.91 | 0.80 | 1.03 |
| Latvia | 0.94 | 0.71 | 1.25 | 1.00 | 0.75 | 1.32 | 1.03 | 0.78 | 1.36 | 1.05 | 0.80 | 1.39 |
| Central Europe | 0.84 | 0.76 | 0.93 | 0.86 | 0.78 | 0.95 | 0.88 | 0.79 | 0.97 | 0.86 | 0.78 | 0.95 |
| Poland | 0.83 | 0.72 | 0.96 | 0.86 | 0.74 | 0.99 | 0.87 | 0.75 | 1.00 | 0.85 | 0.74 | 0.98 |
| Other CE countries | 0.67 | 0.53 | 0.86 | 0.69 | 0.54 | 0.88 | 0.71 | 0.55 | 0.90 | 0.70 | 0.55 | 0.89 |
| Hungary | 0.97 | 0.81 | 1.15 | 0.99 | 0.84 | 1.18 | 1.01 | 0.85 | 1.20 | 0.99 | 0.83 | 1.18 |
| Africa | 0.47 | 0.27 | 0.81 | 0.48 | 0.28 | 0.83 | 0.53 | 0.31 | 0.91 | 0.53 | 0.31 | 0.92 |
| Northern America | 0.82 | 0.70 | 0.96 | 0.83 | 0.71 | 0.98 | 0.87 | 0.74 | 1.02 | 0.88 | 0.75 | 1.04 |
| Latin America | 0.49 | 0.37 | 0.65 | 0.49 | 0.37 | 0.66 | 0.54 | 0.41 | 0.72 | 0.54 | 0.40 | 0.71 |
| Chile | 0.50 | 0.34 | 0.73 | 0.50 | 0.34 | 0.73 | 0.55 | 0.37 | 0.80 | 0.55 | 0.37 | 0.80 |
| South America | 0.48 | 0.32 | 0.74 | 0.49 | 0.32 | 0.75 | 0.53 | 0.35 | 0.81 | 0.53 | 0.35 | 0.80 |
| Asia | 0.60 | 0.51 | 0.70 | 0.60 | 0.52 | 0.70 | 0.65 | 0.56 | 0.76 | 0.66 | 0.56 | 0.77 |
| Turkey | 0.64 | 0.50 | 0.83 | 0.64 | 0.49 | 0.83 | 0.69 | 0.54 | 0.90 | 0.72 | 0.55 | 0.93 |
| Lebanon | 0.62 | 0.31 | 1.23 | 0.61 | 0.30 | 1.21 | 0.67 | 0.33 | 1.33 | 0.70 | 0.35 | 1.40 |
| Iran | 0.66 | 0.45 | 0.97 | 0.68 | 0.46 | 1.00 | 0.72 | 0.49 | 1.06 | 0.68 | 0.47 | 1.01 |
| Iraq | 0.73 | 0.42 | 1.25 | 0.74 | 0.43 | 1.27 | 0.85 | 0.49 | 1.46 | 0.86 | 0.50 | 1.48 |
| Other Asia | 0.52 | 0.40 | 0.67 | 0.52 | 0.40 | 0.68 | 0.56 | 0.43 | 0.73 | 0.57 | 0.44 | 0.74 |
| Russia | 0.87 | 0.71 | 1.06 | 0.89 | 0.73 | 1.08 | 0.91 | 0.74 | 1.11 | 0.91 | 0.74 | 1.11 |

Model 1: adjusted for age and region of residence in Sweden; model 2: + educational level and marital status; model 3: + neighborhood deprivation; model 4: model 3 + comorbidities; Bold values statistically significant.

registered as refugees (for Bosnia (men 16.9%, women 21.7%) and for Iraq (men 17.1%, women 10.0%)).

When analyzing according to high or low risk alcohol regions, interesting differences were found. Men from high alcohol risk regions showed an equal risk as for Swedish-born men, while women from these regions as well as women and men from low alcohol risk regions showed lower HRs than their Swedish-born compatriots. The PAF patterns also differed, with higher PAFs in foreign-born from low alcohol risk regions, i.e. the Middle East, for especially diabetes among both men and women, and also for depression, and for men also for stroke. Diabetes is actually common in the Middle East group in Sweden (Wändell et al., 2008).

Besides, we also found a southern to northern gradient, with a lower risk in the Mediterranean area of Europe, Africa, Latin America and Asia (where most migrants originate from Middle East countries), and a higher risk in Northern and East European countries, and North America. A higher mortality risk in dementia is found in the north of the northern hemisphere, and while the pattern was more complex on the southern hemisphere (Russ, Murianni, Icaza, Slachevsky, & Starr,

2016). Differences in vitamin D levels in relation to dementia has been discussed, but actually vitamin D levels in Europe are higher in the north, in opposite to the expected (Lips, 2007). Besides, vitamin D levels are lower in immigrants from non-European countries in the Nordic countries (Wändell, 2013), including Sweden (Wändell, Ayoob, Mossberg, & Andreasson, 2018). Dietary factors might be of importance, as Mediterranean diet is associated with a preventive effect not only in CHD but in dementia (Lourida et al., 2013). Morbidity and mortality in cardiovascular diseases and especially in CHD has decreased in the Western world during the last decades, including in Europe (Townsend, Nichols, Scarborough, & Rayner, 2015), and in Sweden it is estimated that decreased serum cholesterol levels owing to changed dietary habits was the most important factors (Bjorck, Rosengren, Bennett, Lappas, & Capewell, 2009).

Regarding changes in dietary habits after migration, it was concluded in a review that there is no consistent evidence of what changes that may occur after migration (Wändell, 2013). Dietary changes in migrants could be influenced in different ways depending on the contexts (Bojorquez, Renteria, & Unikel, 2014), such as social position

Table 4
Background factors among Swedish- and foreign-born men aged ≥ 45 years with incident dementia, with adjusted Population Attributable Fraction (PAF).*

| | Swedish-born (n=51,703) | | | | | | Foreign-born (n=4,461) | | | | | |
|-------------------------------------|-------------------------|------------|--------------|-------------|--------------|-------------|------------------------|------------|--------------|------------|--------------|-------------|
| | All ages | | Aged 45–74 y | | Aged ≥ 75 y | | All ages | | Aged 45–74 y | | Aged ≥ 75 y | |
| | Adj. PAF (%) | 95% CI | Adj. PAF (%) | 95% CI | Adj. PAF (%) | 95% CI | Adj. PAF (%) | 95% CI | Adj. PAF (%) | 95% CI | Adj. PAF (%) | 95% CI |
| Hospital diagnosis of hypertension | -6.8 | -7.5; -6.4 | -9.8 | -10.8; -8.8 | -9.8 | -11.1; -9.0 | -4.2 | -6.4; -2.2 | -3.6 | -6.4; -0.9 | -10.3 | -14.8; -6.3 |
| Hospital diagnosis of CHD | -0.2 | -0.7; 0.2 | -2.4 | -3.4; -1.9 | -6.6 | -7.8; -5.8 | 2.3 | 0.3; 4.0 | 2.0 | -0.3; 4.1 | -2.2 | -6.4; 1.7 |
| Hospital diagnosis of heart failure | -0.5 | -4.9; 2.8 | 0.9 | 0.3; 1.5 | -1.9 | -2.9; -0.8 | -8.9 | -30.8; 2.9 | 1.3 | -1.0; 3.4 | -3.3 | -9.6; 1.5 |
| Hospital diagnosis of AF | 0.9 | -3.1; 4.0 | -4.4 | -5.5; -3.1 | -7.3 | -8.7; -5.5 | 6.6 | -2.4; 11.5 | 1.7 | -1.3; 4.4 | -4.9 | -12.9; 1.4 |
| Hospital diagnosis of stroke | 12.7 | 12.4; 13.0 | 12.7 | 12.3; 13.1 | 4.1 | 3.4; 4.8 | 14.9 | 14.0; 15.8 | 16.0 | 15.0; 16.9 | 8.0 | 5.3; 10.3 |
| Hospital diagnosis of obesity | -0.2 | -0.3; -0.1 | -0.1 | -0.2; 0.0 | - | - | 0.0 | -0.3; 0.2 | 0.1 | -0.2; 0.3 | - | - |
| Hospital diagnosis of diabetes | 2.6 | 2.3; 2.8 | 3.2 | 2.8; 3.6 | -0.8 | -1.3; -0.4 | 4.8 | 3.7; 5.8 | 5.0 | 3.7; 6.2 | 2.5 | 0.6; 4.2 |
| Hospital diagnosis of COPD | -0.5 | -0.8; -0.3 | -1.5 | -1.8; -1.1 | -2.0 | -2.5; -1.6 | 0.7 | -0.2; 1.7 | 0.0 | -1.3; 1.1 | -0.1 | -2.2; 1.6 |
| Hospital diagnosis of depression | 4.4 | 4.3; 4.5 | 6.0 | 5.9; 6.1 | 2.1 | 1.9; 2.2 | 6.0 | 5.7; 6.3 | 7.1 | 6.8; 7.4 | 2.8 | 2.1; 3.3 |
| Hospital diagnosis of alcoholism | 2.9 | 2.8; 2.9 | 5.3 | 5.2; 5.4 | 0.7 | 0.6; 0.7 | 5.7 | 5.4; 5.9 | 7.6 | 7.2; 7.9 | 0.9 | 0.4; 1.2 |

Full adjusted model. COPD = Chronic obstructive pulmonary disease; CHD = Coronary heart disease. Ref denotes reference group.

before and after the migration, area of origin, and whether the migrant came from a rural or urban area. In a study of Finnish immigrants in Sweden, a bidirectional pattern was found, with changes in both positive and negative ways concerning dietary habits (Hammar et al., 2009). The same bidirectional patterns are also described in other immigrant groups, e.g. among South Asians in Canada (Lesser, Gasevic, & Lear, 2014), even if adaptation to more Western dietary patterns is common (Parackal, 2017). This adaptation is also associated with a greater risk of diabetes, hypertension and cardiovascular diseases. However, changes to less healthy dietary patterns seem to be more pronounced over time in North America compared to European countries (Popovic-Lipovac & Strasser, 2015). Alcohol intake patterns may be of importance as well, as the Mediterranean area in Europe belongs to the “wine belt”, and northern and eastern Europe to the “vodka belt”

(Messner & Petersson, 1996), and we also found differences in dementia risk in the high and low risk regions of alcohol intake. Besides, it seems that alcohol-related disorders in first-generation immigrants are strongly determined by patterns of alcohol abuse in the country of origin, and that the Finnish group seems to be of special concern (Hjern & Allebeck, 2004).

Other life-style factors could also be of importance for development of dementia. For instance, smoking habits differ between different groups, with high frequency of smokers in many groups, especially among men from the Middle East region (Gadd, Sundquist, Johansson, & Wändell, 2005). Furthermore, physical inactivity is especially common among non-European immigrants, including immigrants from the Middle East Region (Lindstrom & Sundquist, 2001), but also among women from South and East European countries (Gadd et al., 2005).

Table 5
Background factors among Swedish- and foreign-born women aged ≥ 45 years with incident dementia, with adjusted Population Attributable Fraction (PAF).*

| | Swedish-born (n = 73,942) | | | | | | Foreign-born (n = 6607) | | | | | |
|-------------------------------------|---------------------------|------------|--------------|--------------|--------------|--------------|-------------------------|-------------|--------------|-------------|--------------|-------------|
| | All ages | | Aged 45-74 y | | Aged ≥ 75 y | | All ages | | Aged 45-74 y | | Aged ≥ 75 y | |
| | Adj. PAF (%) | 95% CI | Adj. PAF (%) | 95% CI | Adj. PAF (%) | 95% CI | Adj. PAF (%) | 95% CI | Adj. PAF (%) | 95% CI | Adj. PAF (%) | 95% CI |
| Hospital diagnosis of hypertension | -8.6 | -9.5; -8.2 | -12.8 | -14.0; -11.7 | -14.3 | -15.5; -13.8 | -0.7 | -1.0; -0.6 | -8.5 | -11.1; -5.9 | -12.2 | -16.4; -8.9 |
| Hospital diagnosis of CHD | -0.5 | -0.9; -0.2 | -0.6 | -1.1; -0.2 | -3.2 | -3.7; -2.5 | 0.0 | 0.0; 0.1 | 2.4 | 0.9; 3.7 | -1.3 | -3.7; 1.0 |
| Hospital diagnosis of heart failure | -3.6 | -6.7; -0.7 | 1.4 | 1.0; 1.9 | -2.1 | -2.8; -1.3 | 0.3 | -19.8; 11.5 | 1.4 | -0.1; 2.9 | -2.7 | -6.4; 0.5 |
| Hospital diagnosis of AF | 1.3 | -1.0; 3.3 | -4.5 | -5.3; -3.7 | -6.3 | -7.6; -5.1 | -1.9 | -14.1; 5.1 | -3.4 | -6.4; -1.0 | -3.1 | -7.9; 1.1 |
| Hospital diagnosis of stroke | 5.9 | 5.6; 6.2 | 7.4 | 7.0; 7.6 | 1.3 | 0.8; 1.7 | 3.8 | 3.5; 4.1 | 9.2 | 8.3; 10.0 | 5.0 | 3.1; 6.7 |
| Hospital diagnosis of obesity | -0.2 | -0.3; -0.1 | -0.2 | -0.3; -0.1 | 0.0 | -0.1; 0.0 | -8.5 | -16.3; -3.3 | -0.5 | -0.9; -0.1 | - | - |
| Hospital diagnosis of diabetes | 1.5 | 1.2; 1.7 | 1.6 | 1.3; 1.9 | -0.5 | -1.0; -0.3 | 5.4 | 4.3; 6.5 | 4.3 | 3.3; 5.2 | 0.2 | -1.2; 1.4 |
| Hospital diagnosis of COPD | -0.7 | -0.9; -0.5 | -1.1 | -1.4; -0.7 | -1.5 | -1.8; -1.2 | 1.3 | -0.7; 2.9 | 0.1 | -1.0; 1.1 | 0.6 | -1.9; 0.5 |
| Hospital diagnosis of depression | 5.1 | 5.0; 5.2 | 7.4 | 7.3; 7.6 | 2.5 | 2.4; 2.7 | 9.0 | 8.5; 9.4 | 7.7 | 7.4; 8.1 | 2.1 | 1.4; 2.7 |
| Hospital diagnosis of alcoholism | 0.9 | 0.9; 0.9 | 1.9 | 1.8; 1.9 | 0.2 | 0.2; 0.2 | 8.7 | 8.0; 9.3 | 2.6 | 2.4; 2.7 | 0.3 | 0.1; 0.4 |

Full adjusted model. COPD = Chronic obstructive pulmonary disease; CHD = Coronary heart disease. Ref denotes reference group.

However, in women, length of stay in Sweden was associated with physical activity where levels of leisure-time physical activity increased with increasing time since immigration to Sweden (Dawson, Sundquist, & Johansson, 2005).

Regarding the different types of dementia, we found a different distribution compared to what was found in a comprehensive Swedish review (SBU, 2008). We found “other dementia types” to be the most common type, in contrast to the estimated rate of AD of two thirds out of all cases, and VaD to be around double the frequency of 10% according to a review (SBU, 2008). The discrepancy is probably due to an insufficient classification of dementia in the registers when considering the first registered diagnosis, why the categorization should be interpreted with caution.

The healthy migrant effect could be of importance when interpreting the low risk in many groups (Lu & Qin, 2014), even if a Danish study concluded that the healthy migrant hypothesis should be used with caution when interpreting results (Norredam et al., 2014). However, when looking at the low risks among many immigrant groups, it is tempting to ascribe the healthy migrant effect an important role for many migrants, e.g. from Southern and Western Europe, Latin-America, Africa and Asia. Another factor of possible importance is “salmon bias”, i.e. that older and sick migrants return to their country of origin (Lu & Qin, 2014), but another Danish study found no support for this hypothesis (Norredam et al., 2015).

Otherwise, it is difficult from our study to explain both the lower risk in general for dementia among men, and the higher risk in some immigrant groups. The high risk among male immigrants from Bosnia parallels an increased risk for atrial fibrillation (Wändell et al., 2017). We found a diagnosis of alcoholism to have a higher PAF among immigrants, and among foreign-born women. This could be explained by confounding by diagnosis, as those who have memory problems may be investigated and diagnosed with alcoholism to a higher degree than those without memory problems. The rate of alcohol-related dementia was found to be only 1.4% out of all dementia cases in a study of patients in a hospital in New Zealand (Draper, Karmel, Gibson, Peut, & Anderson, 2011).

In the present study we used an exploratory approach when studying different groups of immigrants, as development of a disease such as dementia among immigrants could be influenced by many different factors, including genetic, socio-economic, cultural and lifestyle factors in the country of origin, the reasons for migration, the migration process in itself, and acculturation in the new home-country. Besides, as dementia is much of a disease in the elderly, it will take a considerable amount of time to develop the disorder, making longer follow-ups than what was possible in the present study of interest.

There are several limitations of this study which must be kept in mind when interpreting the results. The categorization of registered types of dementia could be questioned, with an underestimation of the rate of AD and possibly excess estimation of VaD (SBU, 2008), why only the total number of dementia cases is of most interest, especially in the clinical situation. This may be questioned, as patterns of the different dementia diagnoses differ in relation to age-groups and to background factors. The diagnostic procedures have improved over time, why our figures could reflect earlier uncertainties of the exact classification, also including uncertainty in the early stage of a dementia investigation. Besides, all cases of dementia are probably not clinically examined for different reasons, but this is probably less common in the larger cities with a higher access to health care. Assessing PAR or PAF can be performed in different ways, and we decided to use the approach proposed by Miettinen (Miettinen, 1974), a method used also in other studies (Yusuf et al., 2004; Anonymous, 2015), as this gives illustrative information fairly easy to interpret. One disadvantage, however, is that, if summarizing the PAFs, the sum will exceed 100%, which must be kept in mind when interpreting results.

A major strength of this study was the linkage of clinical data (less than 1% missing data) from individual patients to national

demographic and socioeconomic data. The clinical data were highly complete with less than 2% of the total number of diagnoses missing (Sundquist, Chaikiat, Leon, Johansson, & Sundquist, 2011). Furthermore, the comprehensive nature of our data also made it possible to analyse men and women from all types of sociodemographic backgrounds.

In conclusion, in this study of more than 3 million Swedish inhabitants, we found that male immigrants to Sweden in general showed a lower risk of dementia, while female immigrants showed a neutral risk pattern when adjusting for all confounding factors, including comorbidities. However, an increased risk was found in some specific groups: men from Finland, Bosnia, Estonia, Iraq and Russia, and women from Finland and Norway.

Developing dementia in a new country with a different language is a challenge for both patients and the health care system.

Author contribution

PW, ACC, JS and KS designed the study, XL analyzed data, and all authors participated in the interpretation of data; PW and ACC drafted the manuscript and all other authors revised it critically for important intellectual content.

Disclosures

The authors have no conflict of interest to disclose.

Funding

This work was supported by ALF funding awarded to Jan Sundquist and Kristina Sundquist and by grants from the Swedish Research Council (awarded to Kristina Sundquist), the Swedish Council for Working Life and Social Research (Jan Sundquist), and the National Heart, Lung, And Blood Institute of the National Institutes of Health under Award Number R01HL116381 to Kristina Sundquist.

Impact statement

We certify that this work is new. We found a lower dementia risk among immigrants in general, confirming results in earlier Nordic studies, but with higher risks in some specific groups. Men from high-risk alcohol countries showed a similar risk as Swedish-born men, and population attributable fractions (PAFs) differed between high- and low-risk alcohol regions, with much higher PAFs for diabetes and depression, and to some extent also for stroke and atrial fibrillation.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.archger.2019.03.003>.

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