Valvular heart diseases in immigrants and Swedish-born individuals: a national cohort study

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ABSTRACT

Objectives. The aim of this study was to analyse the risk of valvular heart diseases among foreign-born individuals in Sweden. Design. This was a nationwide study of individuals aged 18 years of age and older (N = 6,118,649; 2,970,055 men and 3,148,594 women). Valvular heart diseases were defined as at least one registered diagnosis in the National Patient Register between 1 January 1998 and 31 December 2012. Cox regression analysis was used to estimate hazard ratios (HR) with 99% confidence intervals (CI) of incident valvular heart diseases in foreign-born individuals compared to Swedish natives. The Cox regression models were adjusted for age, co-morbidities, and sociodemographic factors. Sub-categories were chronic rheumatic valvular heart diseases and non-rheumatic valvular heart diseases. Results. There were 64,979 male cases and 59,075 female cases. Fully adjusted HRs (99% CI) were among immigrant men 0.86 (0.82–0.89) and immigrant women 0.96 (0.92–1.00). For chronic rheumatic valvular disease among immigrant men and women, the HRs were 1.62 (1.37–1.92) and 1.75 (1.52–2.00), respectively, and, for non-rheumatic valvular disease among immigrant men 0.83 (0.80–0.87) and immigrant women 0.92 (0.88–0.96). Increased risks for chronic rheumatic valvular disease were found among men from Southern, Eastern and Central Europe, Africa and Asia and among women from Western, Eastern and Central Europe and Africa, Latin America and Asia. Conclusions. We observed lower risks in general of valvular heart disease, but higher risks of chronic rheumatic valvular heart disease in immigrants, which is important in the clinical situation.

Introduction

Valvular heart diseases are important both as causes of congestive heart failure (CHF), and also as heart disorders possible to operate surgically. Globally, valvular heart diseases are most common in Western high income countries and Asian Pacific high income countries, and lower in other regions of the world; however, the prevalence rates vary in East Asia [1].

Valvular heart diseases were historically mainly caused by rheumatic heart diseases as consequences of infections, often by streptococci. However, acute rheumatic fever has decreased during the last decades in the industrialized or developed countries, while still being present in less developed parts of the world [2]. A study from Soweto, South Africa, showed that “historically” prevalent heart diseases, with primary valvular heart diseases predominating within this group (62%), were more common in individuals younger than 50 years of age, women and individuals of “African” descent [3].

Valvular heart diseases has been studied in immigrants and minorities internationally; a US study found that rheumatic heart disease “continues to pose a significant health burden among African Americans and immigrants from developing countries living in multiethnic urban America,” and especially in a more aggressive variant among young adults from developing countries [4]. An Israeli study found a high rate of valvular heart diseases, probably of rheumatic heart disease origin, among Ethiopian teenagers migrating to Israel [5]. Furthermore, a review article on rheumatic mitral stenosis concluded that even if acute rheumatic fever has decreased in Western countries, this trend is now reversing owing to immigrants coming from non-industrialized countries with a higher presence of rheumatic fever [6]. This trend calls for further research on this topic in large, nationwide populations.

The aim of this study was to estimate the risk of valvular heart diseases in general among foreign-born individuals in Sweden compared to Swedish-born individuals. We also...
aimed to study rheumatic valvular heart diseases and non-rheumatic valvular heart diseases separately in foreign-born and Swedish-born individuals.

Methods

We used national Swedish registers, i.e. the National Patient Register (NPR), and the Swedish Total Population Register. The NPR includes diagnoses from all Swedish hospitals, i.e. for in-hospital patients since 1987 and for out-patients from 2001 and onwards. The Total Population Register includes data on country of origin and socio-demographic factors on all Swedish persons with a residence permit.

Study population

We included individuals 18 years of age and older in an open cohort design. Individuals with a diagnosis of a valvular heart disease diagnosed before 1997 were excluded (in total 5086 men and 4963 women) because the current ICD coding of diagnoses was introduced in 1997.

Outcomes

We sub-categorized the main outcome valvular heart diseases into the two groups chronic rheumatic heart diseases (ICD-10 codes I05-I09) and non-rheumatic valvular heart diseases (ICD-10 codes I34-I39).

Socio-demographic variables

The population was stratified by sex.

Age was used as a continuous variable in the analysis. Educational attainment was categorized as ≤9 years (partial or complete compulsory schooling), 10–12 years (partial or complete secondary schooling) and >12 years (attendance at college and/or university).

Geographic region of residence was included to adjust for possible regional differences in hospital admissions and was categorized as (1) large cities, (2) southern Sweden, and (3) 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.

Neighborhood socio-economic level was created using Small Area Market Statistics (SAMS). The average population in each SAMS neighborhood is approximately 2000 people for Stockholm and 1000 people for the rest of Sweden. A summary index was calculated to characterize neighborhood-level socio-economic status (SES). The index was categorized into three groups: more than one standard deviation (SD) below the mean (high socio-economic 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) [7], with neighborhood status classified as high, middle, or low SES, corresponding to the categories low, middle, and high deprivation in the index [8].

Country of origin: foreign-born (first-generation immigrants) and Swedish-born individuals (reference).

Marital status was defined as married and not married.

We used covariates that have been commonly used in earlier studies such as socioeconomic status (education and neighborhood socioeconomic level), which may facilitate comparisons between studies and interpretations.

Co-morbidities

We included the following co-morbidities (with ICD-10 codes): hypertension (I10-I19), coronary heart disease (CHD I20-I25), cardiomyopathy (I42-I43), atrial fibrillation and flutter (I48), congestive heart disease (CHF I50, I11.0), stroke (I60-I69), diabetes mellitus (E10-E14), chronic obstructive pulmonary disease (COPD J40-J47), and cancers (C00-C97).

Statistical analysis

Number of cases of valvular heart diseases was presented for foreign-born and Swedish-born persons and across baseline subject characteristics. Cox regression analysis was used for estimating hazard ratios (HRs) with 99% confidence intervals (99% CI) of incident valvular heart disease in different foreign-born/immigrant groups compared to Swedish-born individuals. To examine that the strength of the associations did not change over time, proportionality assumptions were checked by plotting the incidence rates over time and by calculating Schoenfeld (partial) residuals; these assumptions were fulfilled. We also performed a sensitive analysis of individuals ≤54 years of age and >54 years, and also analysis for different types of rheumatic and non-rheumatic valvular heart diseases. All analyses were stratified by sex. Three models were used: Model 1 was adjusted for age and region of residence in Sweden; Model 2 was adjusted for age, region of residence in Sweden, educational level, marital status, and neighborhood SES; Model 3 was constructed as Model 2 with inclusion of co-morbidities. SAS 9.4 was used for the statistical analyses. Kaplan-Meier curves were used to present inverse risks of diagnosis of valvular heart diseases in Swedish- and foreign-born men and women.

Results

We included 6,118,649 individuals aged 18 years of age and older (2,970,055 men and 3,148,594 women), where 1,034,634 were foreign-born (men 524,139 and 510,495 women). Table 1 shows the characteristics of the study population and number of events. Regarding socio-economic factors and co-morbidities we found some differences (Supplementary Table 1), especially for co-morbid conditions. Unknown neighborhood socio-economic level was present for many foreign-born individuals and was associated with a lower risk of being diagnosed with valvular heart disease. Hospital diagnoses of coronary heart disease, hypertension, cardiomyopathy, atrial fibrillation, and congestive heart disease were associated with increased risk of valvular
COPD denotes chronic obstructive pulmonary disease.

heart disease in both foreign-born and Swedish-born men and women, while COPD was only associated with a higher risk among Swedish-born women. Diabetes was associated with a lower risk of valvular heart disease among Swedish-born men, and stroke with a lower risk among Swedish-born men and women.

In total 124,054 cases of valvular heart disease (64,979 men and 59,075 women) were noted, with 58,508 among Swedish-born men, 6,471 among foreign-born men, 52,894 among Swedish-born women and 6,818 among foreign-born women (Supplementary Tables 1 and 2).

Table 2 shows the overall risk of being diagnosed with valvular heart disease. The fully adjusted HRs (99% CI) among all immigrants were for men 0.86 (0.82–0.89) and 0.96 (0.92–1.00) for women. Many foreign-born groups had lower HRs in all models, i.e. for immigrant men from the Nordic countries, Southern and Eastern Europe, Latin America, Asia and Russia, and for immigrant women from the Nordic countries, and Southern Europe. An increased risk was found among women from Western Europe, Africa, and Asia.

Table 3 shows the fully adjusted HRs categorized into chronic rheumatic and non-rheumatic valvular disease. For chronic rheumatic valvular disease, the fully adjusted HRs among immigrant men were 1.62 (1.37–1.92) and among immigrant women 1.75 (1.52–2.00). The corresponding HRs for non-rheumatic valvular disease among immigrant women were 0.83 (0.80–0.87) and among immigrant women...
Table 3. Valvular heart diseases (in two subgroups) among immigrant men and women vs Swedish-born men and women, respectively, expressed as hazard ratios (HR) with 99% confidence intervals (99% CI), by country of origin.

| Country of Origin | Chronic rheumatic heart diseases | | | | Non-rheumatic valvular heart diseases | | |
|-------------------|----------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
|                   | Obs. | HR | 99% CI | Obs. | HR | 99% CI |
| **Men**           |      |    |        |      |    |        |
| Sweden            | 1853 | 1  |        | 56655 | 1  |        |
| All foreign-born  | 384  | 1.62 | 1.37 | 1.92 | 6087 | 0.84 | 0.80 | 0.87 |
| Nordic countries  | 72   | 0.77 | 0.55 | 1.09 | 2517 | 0.85 | 0.80 | 0.90 |
| Southern Europe   | 26   | 2.15 | 1.21 | 3.79 | 265  | 0.65 | 0.55 | 0.78 |
| Western Europe    | 16   | 0.78 | 0.38 | 1.60 | 697  | 1.06 | 0.95 | 1.18 |
| Eastern Europe    | 55   | 2.19 | 1.47 | 3.26 | 710  | 0.83 | 0.74 | 0.93 |
| Baltic countries  | 8    | 1.16 | 0.42 | 3.18 | 176  | 0.91 | 0.74 | 1.13 |
| Central Europe    | 31   | 1.99 | 1.18 | 3.37 | 440  | 0.91 | 0.79 | 1.04 |
| Africa            | 29   | 4.31 | 2.50 | 7.44 | 178  | 0.84 | 0.67 | 1.04 |
| Northern America  | 5    | 1.08 | 0.30 | 3.86 | 134  | 0.96 | 0.75 | 1.23 |
| Latin America     | 11   | 2.03 | 0.85 | 4.84 | 123  | 0.69 | 0.53 | 0.89 |
| Asia              | 129  | 3.90 | 2.94 | 5.17 | 788  | 0.71 | 0.64 | 0.79 |
| Russia            | 2    | 0.71 | 0.09 | 5.30 | 50   | 0.61 | 0.41 | 0.91 |
| **Women**         |      |    |        |      |    |        |
| Sweden            | 2695 | 1  |        | 50199 | 1  |        |
| All foreign-born  | 590  | 1.75 | 1.52 | 2.00 | 5591 | 0.92 | 0.88 | 0.96 |
| Nordic countries  | 168  | 1.01 | 0.80 | 1.27 | 2865 | 0.87 | 0.82 | 0.92 |
| Southern Europe   | 15   | 1.59 | 0.76 | 3.34 | 135  | 0.71 | 0.56 | 0.91 |
| Western Europe    | 50   | 1.65 | 1.09 | 2.47 | 675  | 1.14 | 1.02 | 1.27 |
| Eastern Europe    | 63   | 2.39 | 1.65 | 3.46 | 434  | 0.91 | 0.79 | 1.05 |
| Baltic countries  | 5    | 0.49 | 0.14 | 1.74 | 182  | 0.98 | 0.79 | 1.21 |
| Central Europe    | 37   | 1.79 | 1.12 | 2.87 | 372  | 0.95 | 0.82 | 1.10 |
| Africa            | 46   | 9.82 | 6.31 | 15.28 | 93  | 1.27 | 0.95 | 1.71 |
| Northern America  | 5    | 0.80 | 0.21 | 2.88 | 80   | 0.76 | 0.56 | 1.02 |
| Latin America     | 28   | 4.32 | 2.50 | 7.49 | 80   | 0.69 | 0.50 | 0.95 |
| Asia              | 162  | 4.81 | 3.73 | 6.20 | 589  | 1.06 | 0.93 | 1.19 |
| Russia            | 11   | 2.22 | 0.94 | 5.24 | 69   | 0.80 | 0.57 | 1.13 |

*Fully adjusted.*

Bold values are statistically significant.

Increased risks for chronic rheumatic valvular disease were found among men from Southern, Eastern and Central Europe, Africa, and Asia, and among women from Western, Eastern and Central Europe and Africa, Latin America, and Asia. For non-rheumatic valvular heart diseases the risk was lower in immigrant men from the Nordic countries, Southern and Eastern Europe, Latin America, Asia, and Russia, and among immigrant women from the Nordic countries, Southern Europe and Latin America, while an increased risk of non-rheumatic valvular heart diseases was found among women from Western Europe.

Table 4 shows the fully adjusted HRs for men and women ≤54 years of age, and ≥55 years of age. The HRs were lower for foreign-born in general for men in both age-groups, and in both age-groups for men from the Nordic countries, and among the older group in men from Southern and Eastern Europe, and from Asia. For foreign-born women the HR was lower in the older age-group in general, and lower in both age-groups for women from the Nordic countries, and in the older age-group for women from Southern Europe. Higher HRs were found in women from Africa and Asia.

Table 5 shows the HRs for different types of rheumatic and non-rheumatic valvular heart diseases. Mitral valvular heart disease were low in numbers, but with higher risk among foreign-born men and women, and to a lesser extent for aortic valvular heart diseases. Non-rheumatic valvular heart diseases showed high numbers, and with lower risk
for aortic valvular heart diseases among foreign-born men and women.

Kaplan-Meier curves (Figure 1a,b) show the inverse risk for being diagnosed with valvular heart diseases in Swedish-born and foreign-born men and women, respectively.

**Discussion**

The main findings of the present study were that the risk of being diagnosed with valvular heart disease in general was lower in foreign-born men and women compared to Swedes, but that the risk of being diagnosed with chronic rheumatic valvular heart disease in general was higher. For chronic rheumatic valvular heart disease, the risk was higher not only in non-European regions such as Africa, Latin America, and Asia, but also in some European regions. The risk for mitral rheumatic valvular heart disease, and to a lesser extent for aortic rheumatic valvular heart diseases, was higher in general for foreign-born men and women although the total numbers were low, while the risk of non-rheumatic aortic valvular diseases was lower but with higher numbers.

The higher risk of being diagnosed with chronic rheumatic valvular heart disease in immigrants from some parts of the world, mostly non-European regions, is not surprising, and was most evident for mitral valvular heart diseases but also for aortic valvular heart diseases. Acute rheumatic fever has certainly decreased during the last decades in industrialized or developed countries, while still being more common in other parts of the world [2]. The higher risk in some immigrant groups has been described earlier, i.e. among immigrants from non-industrialized or developed countries, while still being more common in other parts of the world [4–6]. However, the increased risk in immigrants from some European regions was more surprising.

As regards non-rheumatic valvular heart disease, the risk was lower in many groups, and mostly seen for aortic valvular heart diseases. This could be associated with the healthy migrant effect, i.e. immigrants being able to migrate tend to be healthier than their compatriots in the country of origin [9]. This could be expected for immigrants from European regions and was also found for men and women from Nordic countries and Southern Europe. Besides, the risk of coronary heart diseases has traditionally been lower in the Mediterranean region, and higher in Northern Europe, even

**Table 5. Incidence of specific valvular heart diseases in immigrants vs Swedish-born individuals expressed as hazard ratios (HR) with 99% confidence intervals (99% CI).**

| Diagnosis, ICD-10 code | Swedish | Foreign born | aHR | 99% CI  | Swedish | Foreign born | aHR | 99% CI |
|------------------------|---------|--------------|-----|--------|---------|--------------|-----|--------|
| Mitral stenosis I05.0   | 181     | 115          | 1.49| 1.05–2.1 | 343     | 260          | 1.26| 1.18–1.33|
| Mitral insufficiency I05.1 | 75     | 49           | 1.57| 1.11–2.2 | 145     | 126          | 1.18| 1.00–1.37|
| Aortic stenosis I06.0   | 464     | 25           | 1.86| 1.25–2.7 | 36     | 31           | 1.20| 0.85–1.68|
| Aortic insufficiency I06.1 | 124    | 12           | 2.42| 1.47–3.9 | 19     | 18           | 1.16| 0.70–1.92|
| Other unspecified I05.8, I05.9 | 733   | 52           | 1.42| 1.02–1.9 | 35     | 33           | 1.20| 0.80–1.78|
| Other unspecified I06.8, I06.9 | 777   | 52           | 1.46| 1.04–2.0 | 36     | 33           | 1.20| 0.80–1.78|
| Tricuspid stenosis I07.0 | 385    | 17           | 2.72| 1.62–4.5 | 17     | 13           | 1.49| 0.82–2.69|
| Tricuspid insufficiency I07.1 | 177   | 17           | 1.83| 1.20–2.7 | 23     | 20           | 1.17| 0.73–1.86|
| Tricuspid stenosis with insufficiency I07.2 | 17     | 7            | 2.43| 1.33–4.4 | 10     | 7            | 2.20| 1.16–4.19|
| Other unspecified I07.8, I07.9 | 162   | 27           | 0.98| 0.64–1.49| 19     | 13           | 1.10| 0.76–1.57|

*Full adjusted.
Bold values are statistically significant.
if the risks have approached each other over time. The risk was also, surprisingly, higher in immigrant women from Western Europe.

The risk was higher in some groups, such as in married Swedish-born men and women, foreign-born men with higher educational level, and individuals with unknown neighborhood socio-economic level. This could indicate that some patients with valvular heart disease are undetected longer time than others. In general, unmarried men and women tend to have worse health, but having a spouse reacting on the partner’s health problems may lead to an earlier detection of a disease. Perhaps this could be more evident for a more “visible” disease, however, such as dementia [10].

For the selected co-morbidities, the risk of being diagnosed with valvular heart disease was in general higher, which could be expected. What is surprising is the lower risk for some diseases, such as for diabetes among Swedish-born men, and stroke among Swedish-born men and women. We have no good explanation to this, but one possible explanation could be a better medicinal treatment decreasing the risk of atherosclerotic heart disease, including non-rheumatic valvular disease.

As regards the relation between valvular heart diseases and congestive heart disease (CHF), an earlier Swedish study including patients 45 years of age and older found that the population attributable fraction (PAF) for non-rheumatic valvular heart disease in incident CHF was 5–6% among both foreign- and Swedish-born persons, and for chronic rheumatic heart disease 0.4–1.0%, with slightly higher risks among foreign-born persons [11]. Yet an earlier Swedish study found a rate of valvular heart disease among CHF patients of around 12% among those 18–44 years and 9% among those 45–54 years of age, but with no increased rate over time between 1987–1991 and 2002–2006. The authors also found an increased risk of hospitalization for CHF among those persons 18–54 years of age, mostly due to cardiomyopathy [12]. In Denmark, an increasing rate over time was seen in patients with valvular heart disease among all CHF patients over time, from 4% 1995–1997 to 13% 2010–2012 and with an increasing trend of CHF among younger but a decreasing trend among older patients [13]. Another Swedish study of foreign- and Swedish-born patients with heart failure who were seeking care for worsening symptoms at a university hospital, found a rate of valvular heart disease of 35% among foreign-born and 22% among Swedish-born individuals [14].

As regards atrial fibrillation, the risk in general has been found to be lower among foreign-born men and women in Sweden, both among those ≥45 years of age [15], and <45 years of age [16]. For the younger group, i.e. <45 years of age, the PAFs for non-rheumatic valvular disease in those with incident atrial fibrillation was for Swedish-born vs foreign-born men 4.4% vs 4.9%, and for Swedish-born vs foreign-born women 4.9% vs 12.0% [16]. The corresponding PAFs for chronic rheumatic valvular heart disease was for Swedish-born vs foreign-born men 0.2% vs 3.7%, and for Swedish-born vs foreign-born women 0.7% vs 9.8%.

This study has some limitations. We used the NPR with diagnoses from electronic patient registers and with no possibility to check whether diagnostic criteria had been used. Additionally, we neither had access to data on severity of the valvular heart diseases, nor of the severity of CHF such as NYHA classifications or systolic left ventricular function. Furthermore, we did not have access to diagnostic procedures such as echocardiography or surgical procedures. However, the diagnoses were obtained from hospital diagnoses, where most patients are seen by specialists at least once. Besides, diagnoses from primary care were not included and most patients with comorbidities, such as hypertension and diabetes, are cared for in primary care. Competing risks could potentially be a problem and ignoring competing risks may lead to an overestimation of the cumulative incidence.

The study also has many strengths. For example, we used national Swedish data, and the Swedish registers are shown to have good quality [17,18]. The Swedish personal identity numbers allow linkage between different registers [19], enabling adjustments for many potentially confounding factors. Our study did not suffer from problems with multiple testing since we had a clear objective (comparing immigrants vs. Swedish-born).
In conclusion, we found a lower risk in general among immigrants of being diagnosed with non-rheumatic valvular heart disease. However, for chronic rheumatic valvular heart disease, there was a higher risk in general and especially in some groups from both European and non-European origin. It is important to bear this in mind in contact with immigrant patients in Sweden, where the prevalence of chronic rheumatic valvular heart disease otherwise is low.

Author contributions
PW planned the study, with contribution from ACC, JS and KS; XL conducted the analyses; PW drafted the study, with comments from all other authors; JS and KS had access to the databases, received funding and were responsible for the overall content as guarantors.

Ethical approval
All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent was not applicable, as the study was based on pseudonymized, secondary data from registers. Research data are not shared.

It was not appropriate or possible to involve patients or the public in the design, or conduct, or reporting, or dissemination plans of our research.

The study was approved by the Regional Ethical Review Board in Lund (ref nr 2012/795 and later amendments).

Disclosure statement
No potential conflict of interest was reported by the author(s).

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References
[1] Khatabzadeh S, Farzadfar F, Oliver J, et al. Worldwide risk factors for heart failure: a systematic review and pooled analysis. Int J Cardiol. 2013;168(2):1186–1194.
[2] Kadir IS, Barker TA, Clarke B, et al. Recurrent acute rheumatic fever: a forgotten diagnosis? Ann Thorac Surg. 2004;78(2):699–701.
[3] Stewart S, Carrington M, Pretorius S, et al. Standing at the crossroads between new and historically prevalent heart disease: effects of migration and socio-economic factors in the Heart of Soweto cohort study. Eur Heart J. 2011;32(4):492–499.
[4] Doukky R, Abusin SA, Bayissa YA, et al. Rheumatic heart disease in modern urban America: a cohort study of immigrant and indigenous patients in Chicago. Int J Cardiol. 2014;175(1):178–180.
[5] Fink DL, Chaiter Y, Menahem S, et al. Valvular heart disease in a Young Israeli Ethiopian Immigrant Population From the Gondar Region With Implications for Rheumatic Heart Disease. Front Public Health. 2018;6:130.
[6] Wunderlich NC, Dalvi B, Ho SY, et al. Rheumatic mitral valve stenosis: diagnosis and treatment options. Curr Cardiol Rep. 2019;21(3):14.
[7] Winkleby M, Sundquist K, Cubbin C. Inequities in CHD incidence and case fatality by neighborhood deprivation. Am J Prev Med. 2007;32(2):97–106.
[8] Zoller B, Li X, Sundquist J, et al. Neighbourhood deprivation and hospitalization for atrial fibrillation in Sweden. Europace. 2013;15(8):1119–1127.
[9] Diaz E, Kumar BN. Differential utilization of primary health care services among older immigrants and Norwegians: a register-based comparative study in Norway. BMC Health Serv Res. 2014;14:623.
[10] Wandell P, Carlsson AC, Gasevic D, et al. Socioeconomic factors and mortality in patients with atrial fibrillation—a cohort study in Swedish primary care. Eur J Public Health. 2018;28(6):1103–1109.
[11] Wandell P, Carlsson AC, Li X, et al. Heart failure in immigrant groups: a cohort study of adults aged 45 years and over in Sweden. Scand Cardiovasc J. 2018;52(6):292–300.
[12] Barasa A, Schaufelberger M, Lappas G, et al. Heart failure in young adults: 20-year trends in hospitalization, aetiology, and case fatality in Sweden. Eur Heart J. 2014;35(1):25–32.
[13] Christiansen MN, Kober L, Weeke P, et al. Age-specific trends in incidence, mortality, and comorbidities of heart failure in Denmark, 1995 to 2012. Circulation. 2017;135(13):1214–1223.
[14] Hedemalm A, Schaufelberger M,Ekman I. Reported adherence and social support among immigrants compared to native Swedes. J Immigr Minor Health. 2010;12(1):124–131.
[15] Wandell P, Carlsson AC, Li X, et al. Atrial fibrillation in immigrant groups: a cohort study of all adults 45 years of age and older in Sweden. Eur J Epidemiol. 2017;32(9):785–796.
[16] Wandell P, Carlsson AC, Li X, et al. Atrial fibrillation in immigrants under the age of 45 y in Sweden. Int J Epidemiol. 2019;11(3):193–202.
[17] Ludvigsson JF, Almqvist C, Bonamy AK, et al. Registers of the Swedish total population and their use in medical research. Eur J Epidemiol. 2016;31(2):125–136.
[18] Ludvigsson JF, Andersson E, Ekborn A, et al. External review and validation of the Swedish national inpatient register. BMC Public Health. 2011;11:450.
[19] Ludvigsson JF, Otterblad-Olausson P, Pettersson BU, et al. The swedish personal identity number: possibilities and pitfalls in healthcare and medical research. Eur J Epidemiol. 2009;24(11):659–667.