



Higher prevalence of heart failure in rural regions: a population-based study covering 87% of German inhabitants

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Received: 11 January 2019 / Accepted: 18 February 2019 / Published online: 23 February 2019
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Abstract

Background So far the extent of regional variation of heart failure (HF) prevalence in Germany is unknown.

Methods Using a full sample of nationwide claims data covering ambulatory care of approximately 87% of the German population, this study aimed to (i) examine regional differences of HF prevalence on the level of 402 German administrative districts and (ii) investigate factors associated with HF prevalence. This study included all statutory health-insured patients aged ≥ 40 years in 2017, comprising about 40 million individuals. Age- and sex-standardized HF prevalence was estimated on the district level. Two-level logistic regression analysis was employed to study the influence of the district-related factors degree of urbanisation and regional socio-economic status on HF diagnosis, adjusted for the individual's age and sex.

Results HF prevalence in 2017 was 6.0%. Standardized prevalence on the district level varied by a factor of 4.3 (range 2.8–11.9%). Regional socio-economic status and degree of urbanisation were independently associated with HF prevalence. The prevalence increased with decreasing degree of urbanisation. The adjusted risk of suffering from HF was 40% higher in 'rural areas with a low population density' as compared to 'big urban municipalities' (odds ratio 1.40, 99% CI 1.24–1.59).

Conclusion Strong regional variations in HF prevalence may inform future public health policies regarding targeted resource planning and prevention strategies. High prevalence in areas with low population density adds to the challenge of ensuring universal access to health services in rural German regions.

Keywords Adults · Claims data · Germany · Heart failure · Prevalence

Introduction

Heart failure (HF) is a severe chronic syndrome associated with high health care expenditure and increased mortality [1, 2]. Due to population aging, the burden of HF is growing in industrialized countries [3] and puts an increasing pressure on national health systems. Clinically, HF patients may suffer from various comorbid conditions [4, 5] and adequate comprehensive treatment remains challenging [6]. In Germany HF is the leading cause for hospitalizations [7]

and marked differences of HF associated admission rates between Federal States most likely indicate considerable regional variations of HF prevalence [8]. Furthermore, regional socio-economic disparities [9] and the degree of urbanisation [10] have been shown to be associated with HF prevalence in other industrialized countries. Reliable information on regional variations of HF morbidity is a prerequisite for an informed design of public health policies regarding targeted resource planning and prevention strategies.

Based on ambulatory claims data covering 87% of the German population, this study aimed to assess regional variations of HF prevalence and to examine the association of degree of urbanisation and regional socio-economic status on the district level with HF prevalence, using hierarchical logistic regression analysis.

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Methods

Our study was based on nationwide ambulatory claims data of all statutory health insured (SHI) individuals in 2017, which cover approximately 87% of the total German population. These data contain outpatient diagnoses coded according to the German modification of the International Classification of Diseases (ICD-10-GM) as well as socio-demographic information of individual patients regarding age, sex and district of residence (402 administrative districts). We included all ambulatory patients aged ≥ 40 years in 2017. Patients were considered having HF if they had received the ICD-Codes I50.-, I11.0-, I13.0-, or I13.2- in at least two quarters of 2017. Crude HF prevalence was estimated for Germany as a whole and on a district level. In addition, directly age- and sex-standardized HF prevalence estimates were calculated for each district using the age and sex distribution of the SHI population in 2017 as standard population.

Two-level logistic regression analysis was employed to study the association of the district-related variables degree of urbanisation and regional socio-economic status with HF prevalence, adjusted for the individual's sex and age (5-year age groups). Degree of urbanisation of districts was classified into four categories: 'rural areas with a low population density', 'rural areas with population concentrations', 'urban districts', and 'big urban municipalities'. District level socio-economic status was assessed using the German index of social deprivation [6], which was classified into quintiles. This index is a composite measure of area-based socio-economic indicators, including income, education and employment [11]. A low-regional socio-economic status translates into a high index of deprivation and vice versa. First, the median odds ratio (MOR) was calculated for the empty model, i.e. without any variables as an indicator of unexplained community variance [12]. Second, we included the individual- and district-related variables described above to estimate the association with HF. Effect estimates were reported as adjusted odds ratios (OR) and corresponding 99% confidence intervals (CI). All analyses were conducted using SAS[®] 9.4.

Results

The study population comprised 40,481,732 insured persons aged 40 years or older (Table 1). Overall, 2,440,808 patients met the case definition, which corresponded to a HF prevalence of 6.0%. Median age of HF patients was 78 years (interquartile range 69–84 years), and 54% were female. The standardized HF prevalence varied by the

factor of 4.3 between the district with the lowest (Koblenz, Rhineland Palatinate: 2.8%) and the district with the highest estimate (Hof, Bavaria: 11.9%). Standard deviation of HF prevalence values on the district level decreased by 14% from 2.1 for crude values to 1.8 for age and sex-standardized values. Overall, 66 districts (~ 16%) showed standardized estimates that were more than one standard deviation greater than their mean (6.1%) on the district level. Visual inspection of the regional distribution of HF prevalence revealed a vast high-prevalence-cluster extending from Northern Bavaria to Northern Saxony-Anhalt, almost entirely covering the Eastern German states Saxony-Anhalt and Thuringia (Fig. 1).

The MOR in the empty model amounted to 1.37 suggesting strong regional variation (Table 1). In the final model, men were 1.32 times more likely to suffer from HF than women (99% CI 1.31–1.32, Table 1). The HF risk increased strongly with advancing age. In comparison to insured persons living in districts with the lowest degree of deprivation, the risk of suffering from HF was elevated among those living in all other more deprived regions. However, this risk increase was nonlinear in the adjusted analysis, as the highest chance was observed in the fourth quintile (Table 1). In contrast, prevalence showed a stepwise increment with decreasing degree of urbanisation. The risk of experiencing HF was 40% higher in 'rural areas with a low population density' as compared to 'big urban municipalities' (Table 1).

Discussion

This study was based on a source population comprising 87% of all German inhabitants and is the first to report on regional differences of HF prevalence across German regions. As our results only included individuals with symptomatic HF and since HF patients dying in the first quarter of 2017 could not be captured with the employed case definition, estimates should be considered conservative.

HF prevalence showed strong regional variations, which could partly be attributed to regional differences in socio-demographic composition. Both district-related variables, i.e. regional socio-economic status and degree of urbanisation, were independently associated with HF prevalence. Prevalence of cardiovascular diseases is strongly connected to social determinants [13], and a relatively high HF morbidity has also been shown previously for socio-economically deprived populations in the UK [9]. Likewise, prevalence estimates of diabetes mellitus type 2 and hypertension in North-Eastern Germany gradually increased from areas with the highest to those with the lowest socio-economic status [14, 15]. Both diseases are important risk factors for the later development of HF [16] and their distinct spatial distribution likely contributed to the association between the regional

Table 1 Raw and adjusted odds ratios and corresponding 99% confidence intervals for factors associated with heart failure; results from two-level multivariable logistic regression analysis with more than 40 million individuals (level 1) residing in 402 districts (level 2)

Variables	Total sample <i>n</i> , level 1 = 40,481,732 patients <i>n</i> , level 2 = 402 districts		Adjusted OR	(99% CI)
	Raw OR	(99% CI)		
Fixed effects at the individual level				
Sex: men vs. women	1.08	(1.08–1.08)	1.32	(1.31–1.32)
Age groups				–
40–44 years	Reference			–
45–49 years	1.89	(1.54–1.94)	1.89	(1.84–1.94)
50–54 years	3.38	(3.30–3.46)	3.38	(3.30–3.46)
55–59 years	6.05	(5.91–6.20)	6.04	(5.90–6.18)
60–64 years	10.47	(10.23–10.72)	10.46	(10.22–10.70)
65–69 years	16.51	(16.13–16.89)	16.52	(16.15–16.91)
70–74 years	25.24	(24.67–25.82)	25.34	(24.77–25.93)
75–79 years	38.38	(37.53–39.25)	38.71	(37.85–39.60)
80–84 years	59.78	(58.45–61.14)	60.85	(59.50–62.23)
85–89 years	86.40	(84.46–88.38)	89.37	(87.36–91.42)
90–109 years	112.59	(110.03–115.21)	120.13	(117.40–122.92)
Fixed effects at the district level				
Regional socio-economic status				
Lowest deprivation	Reference			
Low deprivation	1.16	(1.03–1.32)	1.10	(0.97–1.24)
Medium deprivation	1.26	(1.12–1.42)	1.14	(1.01–1.29)
High deprivation	1.42	(1.25–1.60)	1.24	(1.10–1.40)
Highest deprivation	1.44	(1.27–1.62)	1.20	(1.06–1.36)
Place of residence				
Big urban municipalities	Reference			
Urban districts	1.06	(0.94–1.18)	1.08	(0.97–1.21)
Rural areas with population concentrations	1.34	(1.19–1.50)	1.33	(1.18–1.50)
Rural areas with low population density	1.46	(1.30–1.65)	1.41	(1.24–1.59)
Random effects				
Variance from the empty model (standard error)			0.1075	(0.0076)
Variance from the final model (standard error)			0.0851	(0.0077)
MOR from the empty model (credible interval)			1.37	(1.32–1.41)
MOR from the final model (credible interval)			1.30	(1.26–1.35)

MOR median odds ratio, CI confidence interval, significant effects at $p < 0.01$ are depicted using bold letters

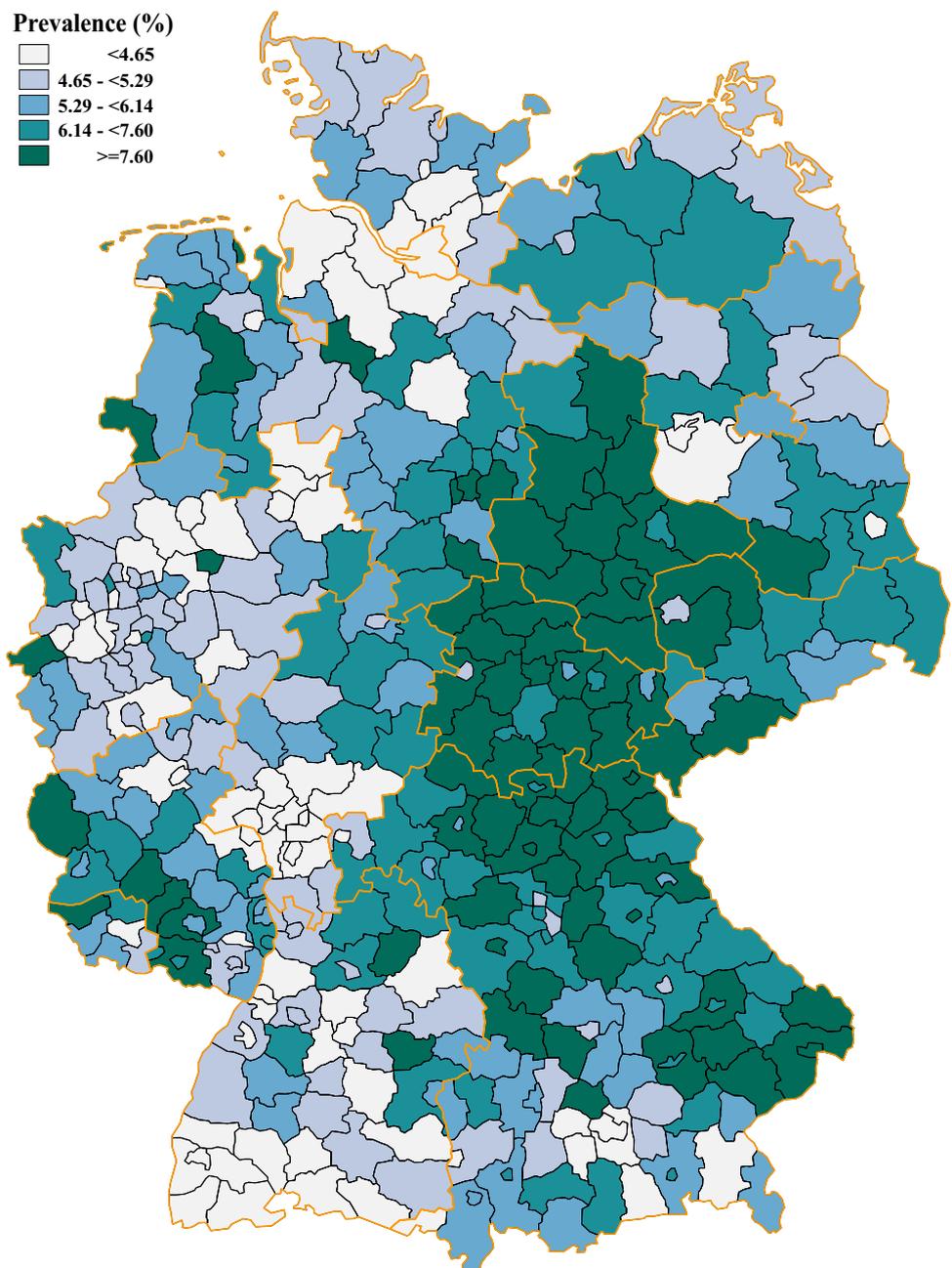
socio-economic status and HF prevalence observed in the present study. Beside that, data on the regional diversity of cardiovascular risk and morbidity in Germany are scarce. Future research might provide further insight by assessing associations of HF risk factors and precursory cardiovascular diseases with HF morbidity on a small spatial scale, including obesity, diabetes, hypertension and ischemic heart disease.

Adjusted for demographic structure, the degree of urbanisation on the district level was inversely related to the risk of experiencing HF. The strength and the stepwise nature of the observed association suggest epidemiological relevance of

this effect. This pattern so far has not been shown for other cardiovascular diseases and risk factors in the German health care setting. Determinants for a higher burden of HF in rural districts may include a higher prevalence of behavioural risk factors, possibly due to selective migration with regard to individual health and health attitudes [17].

The observed high prevalence of HF in rural German regions has considerable implications for the allocation of health care resources. First, in addition to the observed higher HF prevalence in rural regions independently from socio-demographic factors, the disproportionately faster aging of rural populations further adds to this burden.

Fig. 1 Age- and sex-standardized prevalence of heart failure in the year 2017 in 402 German administrative districts, classified into quintiles



Second, ensuring universal access to health care services already poses a major challenge in Germany, as shortage of outpatient physicians—including GPs—in rural regions is looming [18]. Nevertheless, the presented data on regional variations of HF prevalence can provide valuable guidance for the informed planning of health care resources. Furthermore, as a sizable proportion of the observed HF prevalence may be preventable, detailed information on district level prevalence might facilitate the launch of better tailored local public health strategies.

Acknowledgements The authors would like to thank the 17 regional Associations of Statutory Health Insurance Physicians in Germany for provision of data and their support in interpreting the results of our analyses.

Funding None.

Compliance with ethical standards

Conflict of interest JH, MKA, AS and JB declare that they have no conflict of interest. SS receives funding from the German Federal Ministry of Education and Research (01EO1004 and 01EO1504).

Ethical approval In Germany the use of claims data for scientific research is regulated by the Code of Social Law (SGB X). An ethical approval and informed consent are not required as this study used routinely collected anonymized data.

Data sharing statement The datasets analysed during the current study are not publicly available due to data protection regulations by the German Social Security Code (Sozialgesetzbuch (SGB) V).

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