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Prevalence of heart failure in the elderly and future projections: the AGES-Reykjavík study

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Abstract

Objectives—To assess the prevalence of heart failure (HF) in a randomly selected study population of elderly individuals representing the general population of Iceland. Furthermore, to project the number of individuals likely to have HF in the future.

Design—Baseline characteristics and clinical data from 5706 individuals who participated in the population based AGES-Reykjavik Study and gave their informed consent were used. Their age range was 66–98 years (mean age 77.0 ± 5.9 years), 57.6% were females. HF-diagnoses were established by review of hospital records and adjudicated according to prespecified criteria. Data from the ‘Statistics Iceland’ institution on the current size, age and sex distribution of the population and its prediction into the sixth decade were also used.

Results—The prevalence of HF was 3.6% in the sexes combined, but higher in men (5.1%) than women (2.7%) ($p < .001$). The prevalence of HF per age groups 69, 70–74, 75–79, 80–84 and 85 years was 1.7%, 1.5%, 3.7%, 5.2% and 7.2%, respectively. The number of individuals 70 years with HF will increase considerably in the future. Thus, a calculation based on the projected age distribution and increase in the number of elderly 70 years in the coming decades, demonstrated that the number of patients with HF will have increased 2.3-fold by the year 2040 and tripled by the year 2060.

Conclusions—This study, in a cohort of elderly participants representative of the general population in a Nordic country, predicts that HF will be a major and increasing health problem in the coming decades.

Keywords

Heart failure; epidemiology; prevalence; elderly; future projections

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Disclosure statement

The authors report no potential conflict of interest.

Introduction

Heart failure (HF) is a common condition worldwide [1]. Although the age standardized incidence of HF may have declined in recent years due to improved diagnosis and treatment of diseases that cause HF, such as ischemic heart disease and hypertension, subsequently there will be an enlarged population of elderly survivors at risk of developing HF [2]. Furthermore, other conditions that also lead to HF, such as obesity and diabetes are becoming more prevalent [3,4]. The prevalence of HF also increases with age and in view of the ageing of the general population the number of elderly individuals with HF is expected to increase in the future [5,6].

Epidemiological studies on the prevalence of HF have been conducted in various study cohorts, both selected and general populations, using various research methods [1,2,4–6]. Recent reviews have pointed out the discrepancies in the estimated prevalence of HF in previous studies [1,6]. Despite differences in methodology these studies are concordant in predicting increasing prevalence of HF with age [1,2,4–6]. However, few studies have specifically assessed the prevalence of HF in the elderly in an unselected general population [1]. According to recent estimates about 20% of the European population is over the age of 65 years [5]. In the future, the majority of HF patients will be elderly individuals and this will have large health-economical consequences [4–6].

The aim of the current study was to establish the age specific prevalence of HF in a well-defined randomly selected study population of elderly individuals representing the total population of Iceland [7]. In addition, official government projections estimating the size, sex and age distribution of the national population in the coming decades were also available [8]. Combining these datasets, we sought to make a projection on the number of individuals likely to develop HF in the future.

Methods

Study population

The Age, Gene/Environment Susceptibility (AGES) –Reykjavík Study was started in 2002 as a collaboration between the National Institute on Aging in the United States (NIA) and the Icelandic Heart Association (IHA). Its fundamental aim is to examine genetic susceptibility and gene/environment interactions, as these contribute to phenotypes common in old age. The AGES-Reykjavík Study is a subset of the larger population based Reykjavík Study with the primary aim to prospectively assess risk factors for cardiovascular diseases in the Icelandic population [9].

The IHA established the Reykjavik Study in 1967 as a prospective epidemiological survey on cardiovascular disease and its risk factors. The population in Iceland is largely of Nordic origin and ethnically relatively homogeneous. The population now numbers somewhat less than one third of a million, of which more than half lives in the Reykjavík capital area. The standard of living is similar to that of the other Scandinavian countries. The study was longitudinal, running from 1967 to 1994 and collected mid-life data on clinical and biochemical cardiovascular traits from a population based sample of 30.795 randomly

selected individuals born in the years 1907–35 (age range 45 to 74 years), residing in the Reykjavík area. A random sample of 27,281 was invited to participate during different stages (I–V) and 19,381 individuals entered the study and attended examinations. Overall, the participation rate in the study was 72% for men and 80% for women [9].

The AGES- Reykjavík Study randomly selected 8,030 elderly individuals from the surviving 11,459 members of the original Reykjavik Study cohort to assess quantitative traits related to diseases and conditions of old age, and collected genetic and other biologic specimens. To better define phenotypes, molecular markers and contemporary imaging techniques such as echocardiography, computed tomography (CT) and cardiac magnetic resonance, were also used. Incorporation of these methods in conjunction with data already available in the Reykjavik Study greatly improved phenotyping for association studies. Recruitment to the study was started in 2002 and finalized in January 2006. A total of 5,764 participants (58% women) were recruited to the AGES-Reykjavik Study and the response rate was 72%.

Heart failure definition

The current study is a cross sectional evaluation of the prevalence of HF in the participants of the AGES-Reykjavik Study at the time of their recruitment in to the study. The HF diagnoses are based on hospital discharge diagnostic coding (ICD 10). They were verified by review of the hospital records and subsequently adjudicated in accordance with the prespecified criteria of the AGES-Reykjavík Study, defined as major or minor HF criteria (Table 1) [9]. Two major criteria, or one major and two minor criteria, had to be fulfilled to establish a HF diagnosis to be subsequently incorporated into the AGES data bank. An effort was made to determine the underlying cause of HF based on clinical data from hospital records. Fifty-eight participants did not give formal consent for the use of their medical records. Thus, data from 5,706 participants were used in the current study (Figure 1). At the time of inclusion, the age range of the participants was 66–98 years (mean age 77.0 ± 5.9 years) and 58% were females. The mean age was similar in men (77.0 ± 5.7 years) and women (77.0 ± 6.0 years).

The AGES-Reykjavík Study has been approved by the National Bioethics Committee in Iceland in accordance with the Helsinki Declaration and by the National Institute on Aging Intramural Institutional Review Board. Informed consent was obtained for all participants [9]. Official data from the ‘Statistics Iceland’ institution were used to obtain information about the current size, age and sex distribution of the Icelandic population. Prediction for these same factors in to the sixth decade of the 21 century is officially available on-line from the institution [8]. A projection on the number of individuals with HF in the future was done assuming an unchanged age specific prevalence.

Statistics

Univariate comparison between two groups was done using a two-tailed, unpaired t-test or Fischer’s exact test, as appropriate. For prevalence values, exact 95% confidence intervals were computed. A two-tailed *p* value $< .05$ was considered statistically significant. The data analysis was performed using SAS/STAT software, version 9.2 of the SAS System [10].

Results

Study cohort characteristics

The baseline characteristics of the study cohort, divided into those with and without HF-diagnosis, are shown in Table 2. In the group with HF, men were more frequent and the age was higher than in those without HF. Furthermore, more individuals were on treatment for hypertension, had known diabetes and were on medication for HF. The frequency of previous and current smokers combined was similar in those without and with HF. Total cholesterol was lower in the HF group, which was also more often using statins. Their triglyceride-levels, however, were higher. In the group with HF, a family history of myocardial infarction (MI) was more prominent as was a history of prior MI and a Q wave indicative of a previous MI in the electrocardiogram. Of note, over half of the patients with HF were in atrial fibrillation at the time of entry into the study and many of these were on warfarin. The HF group also more frequently had a history of angina pectoris and a previous revascularisation procedure, either coronary artery bypass or percutaneous coronary intervention. Both the coronary artery and aortic valve calcium scores were higher in the HF group and aortic valve replacement had more often been carried out. Those with HF were also characterised by worse kidney function. An echocardiogram was available in the records of 128 (62%) of the HF patients. The mean ($\pm$ SD) ejection fraction (EF) was $46 \pm 15\%$ (range 14–75%); it was $\geq 50\%$ in 59 (46%) and $<50\%$ in 69 (54%) of the patients. Comparing the baseline characteristics of participants with HF and preserved left ventricular ejection fraction (HFpEF) to those with reduced left ventricular ejection fraction (HFrEF), the former group had predominantly females (57%), while the latter had more individuals with atrial fibrillation (65%). Differences in other characteristics did not reach statistical significance due to the small size of the groups.

Prevalence of HF

The age specific prevalence of HF in the sexes separately is detailed in Table 3. Included are both individuals who have HFrEF and HFpEF. The prevalence was higher among men than women in all age groups. Relatively few individuals in the 66–69 year old age group had HF for meaningful statistical interpretation. Therefore, a specific analysis was done on participants who were 70 years of age and older ($n=5170$, females 57%). This gave a prevalence of 3.8% in the sexes combined, 5.1% amongst men and 2.9% in women ($p < .0001$). The prevalence in both sexes combined was 1.5% in the age group 70–74 years and almost four times higher, or 5.8%, in those who were 80 years of age and older.

Predicting the future

Based on data from the ‘Statistics Icelandic’ institution, the number of elderly in the Icelandic population, 66 years of age and older, was estimated in various age groups for the coming decades in both men and women, until 2060 (Figure 2). The largest increase is expected in the age groups 70–79 years and 80 years and older and predominantly in women. Overall, in the year 2013 the number of people aged 66 or older was 11.655 and it was predicted to increase to 28.465 and 39.284 by the years 2040 and 2060, respectively. Thus, by the year 2040 the number of elderly ≥ 66 years in the whole population will have almost doubled and increased 2.5-fold by the year 2060.

Focusing on the population 70 years of age and older, the number of individuals in that age category estimated to have HF and their projected increase until the year 2060, in both sexes, is shown in Figure 3. Most elderly HF patients in the future will be men. The number of elderly individuals 70 years of age and older, projected to have HF, will increase from 1.103 in the year 2013, to 2.585 and 3.294 in the years 2040 and 2060, respectively. Thus, the projected relative increase in the number of individuals with HF at the age of 70 years and older will be 2.3-fold by the year 2040 and will have tripled in 2060 (Figure 4).

Discussion

The current study was conducted in a randomly selected study cohort representative of the Icelandic people, who are a well-defined homogeneous white population of largely Nordic European origin. In Iceland, like in the other Scandinavian countries, health care services are provided by the national social security system, mostly funded by the government and available to every citizen. This includes access to primary health care, referral to specialists and admission to hospitals. Thus, a patient with HF is very likely to be detected in a large population based epidemiological survey like the AGES-Reykjavik Study. Earlier studies and recent reviews have pointed out the discrepancies in the estimated prevalence of HF in various studies, partly due to differing criteria for HF-diagnosis, but also because of the differences in populations investigated and in selection and sampling methods [1,2,4–6,11–13]. It is the main strength of the current study that many of these causes of ambiguity have been minimized. However, although HF is verified clinically, it does not help in distinguishing between patients with HFrEF or HFpEF [14,15]. Recent data show that HFpEF represents more than 50% of HF cases and survival is no better than in those with HFrEF [4]. Although in the current study echocardiography results were only available in 62% of the participants with HF, those with echocardiography results were almost evenly divided between HFrEF and HFpEF. Despite the improved survival over time in patients with HFrEF this is not the case in the vastly heterogeneous group with HFpEF [4]. While the use of medications, like ACE and angiotensin receptor inhibitors, beta-blockers and aldosterone antagonists, along with device therapies, has improved survival in HFrEF, few evidence-based therapies have convincingly been demonstrated to prolong survival in those with HFpEF [4,5]. However, blood pressure lowering therapy and management of other risk factors and comorbidities, may lower the incidence of HFpEF and potentially improve prognosis [4–6].

The current study projects that the number of patients with HF will increase 2 to 3-fold in the coming decades and that more men than women will be affected. The population of Western societies is aging due to increasing longevity, also observed in cardiac patients due to improved medical treatment and other therapeutic innovations. This has led to an increased prevalence of HF, especially in those 80 years and older, that is higher in men than in women [2,4,5,16,17]. The bulk of patients with HF are 65 years or older, accounting for over 80% of prevalent cases and HF deaths in the USA and Europe [4]. More patients survive with coronary heart disease, hypertension and valve disease and this, along with the general aging of the population, will considerably influence the number of patients with HF in the future. A recent estimate from the American Heart Association showed that there were

about 5.8 million people with HF in the United States and worldwide the estimate was about 23 million people [4].

Prevalence estimates that are only based on clinically verified HF are likely to underestimate HF as a public health problem in the future as studies using echocardiography have found that more than half of the participants with LV impairment have no symptoms [6,11]. Furthermore, the prevalence of HFpEF is currently higher than HFrEF, is more prominent in females and is likely to increase in the future [4,14,15]. Concomitantly, with the general increase of the elderly population, more individuals will survive longer with hypertension, atrial fibrillation, obesity and diabetes, all factors that may contribute to HFpEF [1,4,14,16]. It is particularly worrying to note the increase in obesity and diabetes worldwide [3]. In the current study, diabetes and hypertension were more frequent in the HF group. Diabetes, obesity and insulin resistance are associated with the development of HF and diabetes increases the risk of HF about twofold in men and almost fivefold in women. Furthermore, HF patients with diabetes have worse prognosis than those without diabetes. In addition, impaired renal function, as reflected in this study, also confers an increased risk of HF [4].

In the current study a high proportion of HF-patients had some manifestation of coronary artery disease; history of previous MI, angina pectoris, electrocardiographic changes or a prior coronary revascularisation. With increasing age, patients who survive with coronary heart disease are prone to later development of HF [16,17]. In addition, recent cardiac magnetic resonance data from the AGES study have demonstrated that the prevalence of previously unrecognized MI was higher than the prevalence of known MI, more frequent in diabetics and associated with increased mortality risk [18]. These unrecognized MI's were associated with atherosclerosis risk factors, a coronary calcium score indicative of coronary atherosclerosis, history of coronary revascularization and peripheral vascular disease. Yet, compared to participants with recognized MI, those with unrecognized MI were less often on cardiac medications [18]. It is likely that individuals with unrecognized MI may be predisposed to develop HF.

About half of the patients in the current study had atrial fibrillation, a condition that a previous paper on the Icelandic population has predicted to increase considerably in the elderly in the future, thus contributing to an increase in the HF population [19]. A history of a prior aortic valve replacement, mainly due to aortic valve stenosis, and a higher aortic valve calcium score were also more frequent in the HF group. The prevalence of aortic stenosis increases with age and the number of elderly individuals with aortic stenosis has been predicted to increase about 2 to 3-fold in the coming decades [20]. Aortic valve calcification increases with age, predicts the development of significant aortic stenosis, correlates with the coronary artery calcium score and also the Framingham risk score [21–23]. Jointly, these conditions promote the development of HF in the elderly [24,25]. In addition to atrial fibrillation, other conduction abnormalities also increase with age and may hamper LV function and myocardial contractility [25]. Furthermore, age related changes in the myocardium and increased activation of the renin-angiotensin-aldosterone system and the sympathetic autonomic system, are factors that contribute to HF in older individuals [5,25,26].

Patients with HF impose a considerable socio-economical burden on the health care systems of western societies. In the Western world in the 1980's and early 1990's hospitalizations for HF increased considerably, partly due to the general aging of the populations [1,2,4,5]. However, later in the 1990's the incidence of hospitalizations for HF started to decline. The decline in hospitalizations has been attributed to improved medical treatment and management of HF patients causing the average duration of hospitalization and in-hospitality mortality to decline [1,4,5]. In the first decade of the 21st century, however, standardized hospitalization rates have declined in some countries, while in others the overall burden of hospitalizations for HF has increased [27–29].

The two most common causes of HF in the Western world in all age categories are coronary heart disease and hypertension [5]. In general practice, patients with HF are more frequently elderly women, often with hypertension, and more likely to suffer from HFpEF [1,30,31]. Patients with HF attended by a cardiologist, however, are more commonly men in their 60s with a previous history of a myocardial infarction and thus more likely to have HFrEF [1]. Since the prevalence of HF in an unselected population, as reflected in this study, is higher among men, in the future men are likely to outnumber women among HF patients [32,33]. Treatment of coronary heart disease and acute coronary syndromes has been greatly improved in the last two decades. More aggressive invasive treatment with percutaneous coronary interventions and thrombolytic therapy leads to less myocardial damage and more patients surviving with better LV function [34]. However, as these survivors grow older they also develop other concomitant age related disorders that can lead to HF, thus contributing to the increasing prevalence of HF in the future [1,4,29,35].

Limitations of this study

Although this study was conducted in a randomly selected study cohort from a well-defined population, the HF group is relatively small. The diagnostic criteria used to define HF were modified from earlier epidemiological studies and are not in accordance with more recent clinical definitions of HF [1,6,12]. Comprehensive echocardiography and bio-marker data for defining HF were not used. Considering how many patients with impaired LV function can remain asymptomatic until HF develops it is likely that the magnitude of HF in the coming decades may be underestimated by the prevalence data given in this study. Assumptions used to project the age and gender composition and size of the elderly population in the future may change. In some of the participants, hypertension may not have been optimally controlled in line with current standards and this may confound projections for the size of the HF population in the future. Furthermore, assuming an unchanged age specific prevalence in the future projection for the number of individuals with HF may also impose an error.

Conclusions

The number of elderly individuals with HF will largely increase in the coming decades. The current study demonstrates that the main increase, approximately 2- to 3-fold, will be in the age population 70 years and older and more so in males than in females. This same development is predicted in other western societies. The resources needed to cope with age

related health conditions in the large elderly population in the coming decades will have a great health-economical impact. Improved medical treatment for HF patients and progressive development in new technological modalities holds some promise for a better outlook in the elderly with HF in the future [5].

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Figure 1.

A flow chart outlining the recruitment process of the study population.

Figure 2.

The predicted number of elderly individuals in Iceland in the coming decades per age groups and gender.

Figure 3.

The number of individuals 70 years, men and women, projected to have heart failure in the coming decades.

Figure 4.

The projected relative increase in the future of individuals 70 years with heart failure, in both sexes combined. Baseline for the year 2013 is set as 1, when 1103 individuals were estimated to have heart failure.

Table 1

Defined AGES criteria for congestive heart failure.

Need
Two major or
One major and two minor criteria for diagnosis.
Major Criteria
New onset of dyspnea on exertion.
Pulmonary edema on chest film that clears with diuresis.
Minor Criteria
Weight gain >5% of baseline over a two week period.
New appearance of jugular vein distension >3 cm above the sternal-manubrial angle, filling from below.
Pleural effusion not of extra-cardiac etiology.
Reduction in ejection fraction by at least 20%.
Cardiomegaly.

Table 2

Baseline characteristics of HF study subjects.

Variable	Without heart failure <i>n</i> =5499	With heart failure <i>n</i> =207	<i>P</i> -value
Males (<i>n</i> (%))	2301 (41.8)	118 (57)	<.0001
Age (years)	76.9 ± 5.8	80.2 ± 6.1	<.0001
Height (cm)	166.8 ± 9.5	167.5 ± 9.5	.30
Weight (Kg)	75.4 ± 14.7	76.4 ± 15.1	.34
BSA (m ²)	1.84 ± 0.20	1.85 ± 0.20	.48
BMI (kg/m ²)	27.0 ± 4.4	27.2 ± 4.8	.52
Systolic BP (mmHg)	142.5 ± 20.7	139.8 ± 23.1	.07
Diastolic BP (mmHg)	73.9 ± 9.7	71.1 ± 11.5	<.0001
Treated hypertension (<i>n</i> (%))	3435 (62.5)	192 (93)	<.0001
Known diabetes (<i>n</i> (%))	670 (12.3)	56 (28.1)	<.001
Prior or current smoking (<i>n</i> (%))	2953 (53.7)	117 (56.5)	.44
Se-Total cholesterol (mmol/l)	5.65 ± 1.15	5.13 ± 1.25	<.0001
Se-Triglycerides (mmol/l)	1.22 ± 0.67	1.45 ± 1.00	<.0001
Family history of MI (<i>n</i> (%))	1824 (35.7)	79 (48.5)	.134
History of angina pectoris (<i>n</i> (%))	695 (13.4)	67 (40.6)	<.0001
In atrial fibrillation (<i>n</i> (%))	433 (7.9)	108 (52.2)	<.0001
CABG before (<i>n</i> (%))	353 (6.4)	54 (26.1)	<.0001
PCI before (<i>n</i> (%))	355 (6.5)	26 (12.6)	.0015
MI before (<i>n</i> (%))	618 (11.2)	97 (46.9)	<.0001
ECG prior Q wave MI (<i>n</i> (%))	276 (5.3)	28 (16.2)	<.0001
Coronary calcium Agatston score	696 ± 1031	1547 ± 1601	<.0001
Aortic valve calcium score	102 ± 348	258 ± 943	<.0001
Prior aortic valve replacement (<i>n</i> (%))	39 (0.7)	11 (5.3)	<.0001
GFR (mL/min/1.73 m ²)	63.9 ± 15.3	52.6 ± 19.0	<.0001
On ACE blocker (<i>n</i> (%))	694 (12.6)	66 (31.9)	<.0001
On AT-II blocker (<i>n</i> (%))	759 (13.8)	47 (22.7)	.0007
On beta blockers (<i>n</i> (%))	1883 (34.2)	101 (48.8)	<.0001
On digoxin (<i>n</i> (%))	136 (2.5)	58 (28.0)	<.0001
On warfarin (<i>n</i> (%))	297 (5.4)	64 (30.9)	<.0001
On statins (<i>n</i> (%))	1166 (21.2)	76 (36.7)	<.001

ACE: angiotensin converting enzyme; AT: angiotensin; BMI: body mass index; BP: blood pressure; BSA: body surface area; CABG: coronary artery bypass graft. COPD: chronic obstructive pulmonary disease; ECG: electrocardiogram; GFR: glomerular filtration rate; LV: left ventricular; MI: myocardial infarct; PCI: percutaneous coronary intervention. Continuous data are mean ± SD.

Table 3

The prevalence (%) of heart failure per age groups and gender.

Age group (years)	Males (with HF/all)	Prevalence (%) (95% CI)	Females (with HF/all)	Prevalence (%) (95% CI)
66–69	5/191	2.6 (0.9–6.0)	4/345	1.2 (0.3–2.9)
70–74	17/697	2.4 (1.4–3.9)	7/912	0.8 (0.3–1.6)
75–79	33/710	4.6 (3.2–6.5)	26/871	3.0 (2.0–4.3)
80–84	42/560	7.5 (5.5–10.0)	28/793	3.5 (2.4–5.1)
85	21/261	8.0 (5.0–12.0)	24/366	6.6 (4.2–9.6)

CI: confidence interval; HF: heart failure.