Trends in survival of Swedish men and women with heart failure from 1987 to 2014: a population-based case–control study

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Abstract

Aims To compare trends in short-term and long-term survival of patients with heart failure (HF) compared with controls from the general population.

Methods and results We used data from the Swedish National Inpatient Registry to identify all patients aged ≥18 years with a first recorded diagnosis of HF between 1 January 1987 and 31 December 2014 and compared them with controls matched on age and sex from the Total Population Register. We included 702,485 patients with HF and 1,306,183 controls.

In patients with HF aged 18–64 years, short-term (29 days to 6 months) and long-term mortality (>11 years) decreased from 166 and 76.6 per 1000 person-years in 1987 to 2000 to 99.6 and 49.4 per 1000 person-years, respectively, in 2001 to 2014. During the same period, mortality improved marginally, in those aged ≥65 years: short-time mortality from 368.8 to 326.2 per 1000 person-years and long-term mortality from 219.6 to 193.9 per 1000 person-years. In 1987–2000, patients aged <65 years had more than three times higher risk of dying at 29 days to 6 months, with an hazard ratio (HR) of 3.66 [95% confidence interval (CI) 3.46–3.87], compared with controls (P<0.0001) but substantially higher in 2001–2014 with an HR of 11.3 (95% CI 9.99–12.7, P<0.0001). HRs for long-term mortality (6–10 and >11 years) increased moderately from 2.49 (95% CI 2.41–2.57) and 3.16 (95% CI 3.07–3.24) in 1987–2000 to 4.35 (95% CI 4.09–4.63) and 4.11 (95% CI 3.49–4.85) in 2001–2014, largely because survival among controls improved more than that among patients with HF (P<0.0001).

Conclusions Absolute survival improved in HF patients aged <65 years, but only marginally so in those aged ≥65 years. Compared with controls, both short-term and long-term relative risk of dying increased, especially in younger patients with HF.

Keywords Heart failure; Survival; Mortality; Trends; Population; Epidemiology

Introduction

Heart failure is a common clinical syndrome with high morbidity and mortality and is associated with high healthcare costs. In Sweden and other high-income Western countries, the prevalence of heart failure in the adult population is estimated at about 1–2%. Although heart failure prevalence and incidence are highest in elderly people, increased incidence and hospitalization among younger patients have been reported in Sweden and Denmark. Similar trends were seen in Canada, but only in younger men, but not in younger women. In the last few decades, new treatments for heart failure have been developed, and general management has improved. However, the medical and other treatment options (such as devices and pacemakers) have mainly been developed for patients with heart failure and reduced...
ejection fraction (HFrEF),\(^6\) which is more common in younger patients.\(^7,8\) In patients with heart failure and preserved ejection fraction (HFpEF), which is more common in women and older patients, management has not advanced to a similar degree, and the prognosis remains poor.\(^8,9\)

With the increasing life expectancy worldwide, the number of patients with heart failure will rise, and improved survival of heart failure patients will potentially contribute to a larger population of people with this condition. Among heart failure patients in Sweden, survival increased until the first few years of the new millennium,\(^3,10\) but not thereafter. Hence, continuing improvement between 2006 and 2010 was seen among heart failure patients in the Stockholm region.\(^11\) A recent study from the United Kingdom found modest improvements in survival from 2002 to 2017.\(^12\)

The extent to which long-term survival of patients with heart failure has changed in relation to that of other people has not been investigated in unselected patients hospitalized with heart failure in Sweden or elsewhere. In the present study, we aimed to determine the short-term and long-term mortality of patients discharged with a diagnosis of heart failure compared with controls from the general population.

**Methods**

**Study design and participants**

Sweden has a mainly publicly financed healthcare system, with low out-of-pocket costs for hospitalizations, procedures, and prescription drugs. The Swedish National Inpatient Registry contains complete records for all principal and contributory diagnoses for all hospitalizations since 1987 and has high validity in general and for heart failure in particular (85–95% accuracy compared with patient records).\(^13,14\) Using this inpatient registry, we identified and included all patients aged ≥18 years with a first recorded hospitalization, of heart failure between 1 January 1987 and 31 December 2014. For each heart failure case, up to two controls without any prior hospitalization for heart failure, matched by age, sex, and county, were selected from the Swedish Total Population Registry. Data on times and causes of death were derived from the Cause of Death Registry.

All cases of heart failure (main and contributory diagnoses in any position) and all comorbidities were defined according to International Classification of Diseases (ICD)-9 and ICD-10 codes. Heart failure was defined by 428 for ICD-9, and I50 for ICD-10 (Supporting Information, Table S1).

All data were anonymized: the study was approved by the Regional Ethical Review Board in Gothenburg, Sweden (Dnr: 026-16). The research conforms with the principles outlined in the Declaration of Helsinki.

**Statistical analysis**

The study period started on 1 January 1987 and ended on 31 December 2014. All patients were followed from first hospitalization for heart failure in the inpatient registry (baseline) until death or end of follow-up, whichever occurred first. Baseline characteristics are shown as count (percentage) for dichotomous and categorical data and as mean (standard deviation) for numerical variables. A \(P\) value of <0.05 was considered significant. To determine survival probability after heart failure, the study was split into two periods (1987–2000 and 2001–2014), and the cohort was stratified into two age groups (18–64 years and ≥65 years). Probability of survival was modelled by the Kaplan–Meier method.

For assessment of mortality after heart failure, follow-up data were divided into five periods: 29 days to 6 months, >6 months to 1 year, >1 to 5 years, >5 to 10 years, and >10 years. All-cause mortality rates and corresponding 95% confidence intervals (95% CIs) per 1000 person-years were calculated. Differences in mortality between patients and controls were assessed by Cox proportional-hazards regression to estimate the relative risks of mortality. Multivariable Cox regression was performed to evaluate the impact of sex, age, and baseline comorbidity on the survival times in heart failure cases from period 1987 to 2000 comparing to cases from 2001 to 2014. Survival was modelled by the Kaplan–Meier method.

All statistical analyses and data management were performed with SAS statistical software, version 9.4 (SAS Institute, Cary, NC), and all graphs were created using R Version 3.1.3 (http://R-project.org).

**Results**

In total, we included 702 485 patients with a first hospitalization for heart failure (49.8% men; 50.2% women) and 1 306 183 matched controls (49.4% men; 50.6% women) from the general population without prior heart failure. Table I shows the baseline characteristics, including comorbidities and heart failure risk factors for the two periods (1987–2000 and 2001–2014). Among patients with heart failure, women comprised about 32% of the younger patients aged 18–64 years and about 53% of the older patients aged ≥65 years, with little difference between the two periods. The mean age for patients aged 18–64 years was about 56 years in both periods and in those aged ≥65 years about 80 years in both periods, with the majority (88.7%) of all heart failure patients aged ≥65 years (Tables 1 and S2).
Changes in comorbidities and heart failure risk factors

Overall, patients with heart failure had more comorbidities and heart failure risk factors than controls, including not only ischaemic heart disease, hypertension, atrial fibrillation, diabetes, valvulopathy, and cardiomyopathy but also stroke (Table 2). In patients aged <65 years, recorded diagnoses of hypertension, atrial fibrillation, and cardiomyopathy increased from 20.7%, 19.3%, and 7.6% in 1987–2000 to 41.1%, 27.9%, and 12.3% in 2001–2014 (all \( P < 0.0001 \)). All other comorbidities and heart failure risk factors increased significantly \( (P < 0.0001) \) except cancer where there was no significant change \( (P = 0.41) \). During same time frame, the most conspicuous change among controls was observed for hypertension, which increased from 4.0% to 8.3% in the second period \( (P < 0.0001) \).

All recorded comorbidities and heart failure risk factors increased significantly \( (P < 0.0001) \) in patients aged \( \geq 65 \) years, likely at least partly due to changing coding practices. The prevalence of hypertension tripled \( (17.9\% \text{ to } 52.1\%, P < 0.0001) \) and atrial fibrillation almost doubled \( (26.4\% \text{ to } 44.1\%, P < 0.0001) \) from 1987–2000 to 2001–2014. In addition, the prevalence of valvulopathy \( (7.1\% \text{ to } 13\%) \), cancer \( (16.1\% \text{ to } 25.6\%) \), diabetes \( (17\% \text{ to } 21.8\%) \), and chronic obstructive pulmonary disease/asthma \( (12.4\% \text{ to } 17.3\%) \) increased significantly \( (P < 0.0001) \) in controls aged \( \geq 65 \) years, all comorbidities and heart failure risk factors increased significantly \( (P \text{ values } < 0.0001) \) except cardiomyopathy that decreased from 0.04% to 0.02% \( (P < 0.0001) \).

Survival and mortality in patients with heart failure compared with controls from the general population

Figures 1 and 2 show the survival curves after a heart failure diagnosis in patients aged 18–64 years and \( \geq 65 \) years, respectively. Survival improved in younger patients with heart failure, while survival in older patients showed virtually no improvement between the two periods, despite better survival in controls in the later period.

Overall, the mortality rates were higher during the first 29 days to 6 months after discharge with a heart failure diagnosis. In patients younger \( (< 65 \) years) with heart failure, the mortality rates for 29 days to 6 months were 166 and 99.6 per 1000 person-years in 1987–2000 and 2001–2014, respectively, compared with 45.4 and 8.8 per 1000 person-years in the controls. Long-term mortality \( (> 11 \) years) decreased from 76.6 per 1000 person-years in 1987–2000 to 49.4 per 1000 person-years in 2001–2014 in patients, while mortality rates in controls decreased even further (from 24.6 to 12 per person-years) (Table 2).
In younger patients with heart failure, the risk of dying was almost four times higher than that in controls [hazard ratio (HR) 3.66, 95% CI 3.46–3.87, \(P < 0.0001\)] at 29 days to 6 months in 1987–2000 (Table 2). Because the decreasing death rates in controls, the relative risk of death at 29 days to 6 months in patients with heart failure increased (HR 11.3, 95% CI 9.99–12.7, \(P < 0.0001\)) in 2001–2014. Notably, although the absolute mortality rates during follow-up improved in heart failure patients, the relative risk compared with controls increased, for long-term mortality (>11 years) increased from 3.16 (95% CI 3.07–3.24) in 1987–2000 to 4.11 (95% CI 3.49–4.85, \(P < 0.0001\)) in 2001–2014. To compare the risk in the first period (1987–2000) and the second period (2001–2014), we included time period in the multivariable Cox regression model. The relative risk of death was significantly higher in the first period with a HR of 1.54 (95% CI 1.51–1.57, \(P < 0.0001\)) in patients with heart failure <65 years and a HR of 1.24 (95% CI 0.23–1.24, \(P < 0.0001\)) in those aged \(\geq 65\) years.

The mortality rates in patients aged \(\geq 65\) years improved marginally from 368.8 to 326.2 per 1000 person-years at 29 days to 6 months from 1987–2000 to 2001–2014, while long-term mortality (>11 years) decreased slightly more from 219.6 to 193.9 per 1000 person-years during the same time frame. During the first 10 years of follow-up, the HRs for heart failure patients compared with controls were consistently higher in 2001–2014 compared with 1987–2000 (Table 2).

Table 3 shows all-cause mortality and causes of death in the patients with heart failure and controls in 1987–2000 and 2001–2014 until the end of the study. Only one in five of patients aged 18 to 64 identified in 1987 to 2000 was still alive at the end of the second study period, and virtually none of the older patients. Notably, in only a small proportion of all patients was heart failure stated as the underlying cause of death. In patients aged \(\geq 65\) years, heart failure was the cause of death in about 2.5% of the cases with no significant increase (\(P = 0.70\) from 1987–2000 to 2001–2014), whereas in those \(\geq 65\) years, there was a minor increase (7.4% to 8.7%, \(P < 0.0001\)). These results further emphasize the heterogeneities in the causes and multiple comorbidities in this disorder. The proportion of deaths from ischaemic heart disease decreased between the periods in both patients with heart failure and controls.

**Discussion**

This large nationwide register study, including more than 700,000 patients with heart failure and about 1.3 million matched controls from the general Swedish population, showed that even though mortality rates from heart failure decreased from 1987 to 2014, short-term and long-term mortality remained high. While survival improved in younger
patients with heart failure aged <65 years, survival only improved marginally in older patients aged ≥65 years, who constituted the absolute majority of all patients. The general improvement in life expectancy among the Swedish general population was not evident to the same extent in patients with heart failure. This is in line with official statistics from the Swedish Board of Health and Social Welfare which shows that age-adjusted mortality in adults aged <65 years decreased by over a third between 1997 and 2019. Notably, the relative risk in heart failure patients compared with controls increased markedly between the two periods, with an increasing difference in survival between people with and without heart failure.

During the study period, the mortality rates in heart failure patients initially decreased in the first period in 1987–2000, but showed no further reduction during the second period 2001–2014. These results are consistent with a recently published paper from the United Kingdom, which showed a
modest improvement in survival among patients diagnosed with heart failure after 2001. A study from the United States showed an increase in deaths from heart failure in the general population, but it was unclear whether this arose from an increase in incident heart failure or poorer survival. A recently published systematic review showed that short-term mortality from any cause in patients hospitalized for acute heart failure decreased over the past four decades but did not describe prognosis beyond the first year. In the present study, we also found that all-cause deaths declined from the first period (1987–2000) to the second period (2001–2014), most markedly in younger patients.

Compared with controls from the population, both short-term and long-term mortality were higher in patients with heart failure, and because survival improved more markedly in controls than in patients, the relative risk of dying increased in patients between the two periods. For example, in younger patients, the risk of dying at 29 days to...
Table 2  Mortality rates and relative risks of death in patients with heart failure compared with controls from the general population by age group and period

| Time period        | Mortality ratea | HR (95% CI)          | P value | Mortality ratea | HR (95% CI)          | P value | Mortality ratea | HR (95% CI)          | P value |
|--------------------|----------------|----------------------|---------|----------------|----------------------|---------|----------------|----------------------|---------|
|                    | HF patients    | Controls             |         | HF patients    | Controls             |         | HF patients    | Controls             |         |
| 1987–2000          |                |                      |         |                |                      |         |                |                      |         |
| 29 days–6 months   | 346.7          | 111.5                | <0.0001 | 166.0          | 45.4                 | <0.0001 | 368.8          | 119.7                | <0.0001 |
| 7–12 months        | 222.2          | 121.4                | <0.0001 | 105.2          | 50.0                 | <0.0001 | 237.7          | 130.9                | <0.0001 |
| 1–5 years          | 223.1          | 123.8                | <0.0001 | 88.1           | 45.1                 | <0.0001 | 246.4          | 137.3                | <0.0001 |
| 6–10 years         | 170.0          | 90.5                 | <0.0001 | 65.5           | 26.3                 | <0.0001 | 202.4          | 108.9                | <0.0001 |
| ≥11 years          | 157.0          | 81.6                 | <0.0001 | 76.6           | 24.6                 | <0.0001 | 219.6          | 120.1                | <0.0001 |
| 2001–2014          |                |                      |         |                |                      |         |                |                      |         |
| 29 days–6 months   | 296.3          | 73.6                 | <0.0001 | 99.6           | 8.8                  | <0.0001 | 326.2          | 84.1                 | <0.0001 |
| 7–12 months        | 193.6          | 80.5                 | <0.0001 | 66.1           | 10.1                 | <0.0001 | 215.0          | 92.5                 | <0.0001 |
| 1–5 years          | 203.0          | 87.3                 | <0.0001 | 56.8           | 11.7                 | <0.0001 | 235.5          | 103.7                | <0.0001 |
| 6–10 years         | 151.5          | 66.9                 | <0.0001 | 48.2           | 11.1                 | <0.0001 | 193.2          | 86.5                 | <0.0001 |
| ≥11 years          | 136.2          | 68.4                 | <0.0001 | 49.4           | 12.0                 | <0.0001 | 193.9          | 98.3                 | <0.0001 |

CI, confidence interval; HF, heart failure; HR, hazard ratio.

Per 1000 person-years.
Cancer, 
Heart failure, 
Other causes, 
Injuries, 

HF patients aged 18–64 years

| Year | Cause of death | n (%)       | P value |
|------|----------------|-------------|---------|
| 1987–2000 | 30 125 (79.8) | 13 660 (32.9) | <0.0001 |
| 2001–2014 | 30 125 (100) | 13 660 (100) |         |

| Year | Cause of death | n (%)       | P value |
|------|----------------|-------------|---------|
| 1987–2000 | 686 (2.28) | 362 (2.65) | 0.180   |
| 2001–2014 | 11 033 (36.6) | 3518 (25.8) | <0.0001 |

| Year | Cause of death | n (%)       | P value |
|------|----------------|-------------|---------|
| 1987–2000 | 1375 (4.56) | 487 (3.57) | <0.0001 |
| 2001–2014 | 4547 (15.1) | 1853 (13.6) | <0.0001 |

| Year | Cause of death | n (%)       | P value |
|------|----------------|-------------|---------|
| 1987–2000 | 4082 (13.6) | 2506 (18.4) | <0.0001 |
| 2001–2014 | 1905 (6.32) | 1583 (11.6) | <0.0001 |

| Year | Cause of death | n (%)       | P value |
|------|----------------|-------------|---------|
| 1987–2000 | 6497 (21.6) | 3351 (24.5) | <0.0001 |
| 2001–2014 | 6497 (21.6) | 3351 (24.5) | <0.0001 |

CVD, cardiovascular disease; HF, heart failure; IHD, ischaemic heart disease.

**Conclusions**

Absolute survival of heart failure patients improved between 1987 and 2014 among those aged 18–64 years, but improved only marginally among those aged ≥65 years. During the study period, mortality rates in the general population decreased markedly and therefore criteria and large subgroups of patients with HFrEF still lack specific therapies to improve survival. Taken together, this could contribute to an explanation for why there was no reduction in mortality from 2001 to 2014 in older patients. Moreover, clinical studies have mainly focused on patients with HFrEF, who tend to be younger and more often men, while there has been less improvement in treatment in older patients who are more likely to have HfPEF.

In contrast to the limited improvement in prognosis among older patients, net survival in younger patients increased. Compared with older patients, younger patients more often have reduced left ventricular ejection fraction, which is the category of patients for whom treatment has demonstrated to improve survival. Even so, heart failure is rare in young people, with the large majority of heart failure patients being at an age where little improvement was observed. Treatment in younger patients has the potential to be more ambitious, and fulfillment of treatment goals may be more frequently achieved. With an estimated heart failure prevalence of 10–20% among people aged ≥70 years, improved prevention and management of heart failure in these patients should be a public health priority.

**Strengths and limitations**

The present study has several strengths and some limitations. First, this nationwide register study included more than 700 000 patients hospitalized for heart failure over a long time period and matched these patients with controls from the general population with nearly complete coverage of the population in Sweden (>99%). The validity of a heart failure diagnosis in the inpatient registry was shown to be high. In addition, data on times and causes of death were obtained from the Cause of Death Registry with virtually complete coverage. The registered diagnoses of more severe conditions as heart disease, stroke, and cancer are likely correct, but the incidence of hypertension and diabetes is probably underestimated, particularly during the first period. Furthermore, in younger people, heart failure may have remained undiagnosed, especially among those with obesity, because the symptoms associated with obesity and heart failure can be difficult to distinguish. Because obesity is less predominant in older patients with heart failure, therefore, this factor is unlikely to have influenced the results to any great extent.
relative short-term and long-term survival in patients with heart failure relative to controls deteriorated, particularly among younger patients.

**Conflict of interest**

Lena Björck, Carmen Basic, Christina E. Lundberg, Tatiana Zverkova Sandström, Maria Schaufelberger, and Annika Rosengren declare that they have no conflict of interest.

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**Supporting information**

Additional supporting information may be found online in the Supporting Information section at the end of the article.

**Table S1.** International Classification of Diseases ICD-9 and ICD-10 codes used to identify comorbidities in the National Patient Register.

**Table S2.** Baseline characteristics of patients with heart failure and controls from the general population by age and sex.

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