Validity of heart failure diagnoses made in 2000–2012 in western Sweden

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Abstract

Aims The aim of this study is to validate a diagnosis of heart failure (HF) according to the European Society of Cardiology (ESC) guidelines among patients hospitalized at Sahlgrenska University Hospital, Gothenburg, Sweden, between 2000 and 2012.

Methods and results In Sweden, it is mandatory to report all hospital discharge diagnoses to the Swedish national inpatient register. In total, 27 517 patients were diagnosed with HF at the Sahlgrenska University hospital between 2000 and 2012. Altogether, 1100 records with a primary (n = 550) or contributory (n = 550) diagnosis of HF were randomly selected. The diagnosis was validated according to the ESC guidelines from 1995, 2001, 2005, and 2008, and cases were divided into three groups: definite, probable, and miscoded. In total, 965 cases were validated, while 135 records were excluded for various reasons. Of the 965 records, the diagnosis was validated as definite in 601 (62.3%) and as probable in 310 (32.1%); only 54 (5.6%) of cases had been miscoded. Echocardiography, as an objective evidence of cardiac dysfunction, had been performed in 581 (96.7%) of the definite, 106 (34.2%) of the probable, and 31 (57.4%) of the miscoded cases. Among the probable cases, the main reason they had not been classified as a definitive diagnosis of HF was lack of examination by echocardiography (63.8%).

Conclusions The overall validity of HF diagnosis at Sahlgrenska University Hospital is high. This may reflect high diagnostic validity at the time of diagnosis in the national Swedish patient register, supporting the continued use of this register in epidemiological research.

Keywords Heart failure; Diagnosis; Validation; Co-morbidities; Echocardiography

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Introduction

Heart failure (HF) is a common and serious disorder with a prevalence of approximately 2% in the Swedish population. Although the total age-adjusted incidence of HF in Sweden has decreased since 1993,1,2 there has been an increase among younger individuals.3,4 HF is costly, and treatment is estimated to consume 5.0–6.7 billion Swedish krona (SEK) per annum, of which half is spent on in-hospital and nursing home care.5

Accurate estimates of HF prevalence, incidence, and prognosis are important, as the national health care service must be able to plan ahead and prepare for this large group of patients. HF is the most common in-hospital diagnosis in adults, and the unexpected finding that HF is increasing among the young is alarming. Because HF is rare in the young, studying this trend requires large populations or nationwide samples. However, a valid diagnosis is key when evaluating whether information from national databases is credible, and accuracy of the data is also important in planning for the best possible care. Diagnosis validity is central to scientific work and all types of statistical analysis.6

The cardinal symptoms of HF have high sensitivity but low specificity and are similar to those of multiple other

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conditions. Several guidelines and diagnostic criteria are available to assist in diagnosing HF, including the Framingham criteria, the Boston criteria, the Carlson criteria, and the diagnostic criteria of the European Society of Cardiology (ESC). The ESC guidelines were used in one of the few existing published studies in which hospitalization data of men in the 1976–2001 Swedish patient registry were validated against patient records. However, more recent studies and in both sexes are lacking.

Data from the national Swedish patient registry, as well as from other administrative registries in countries where such data exist, are increasingly being used for research purposes. Current and former ESC guidelines list diagnostic criteria that are updated from one version to the next, and validation studies have been performed using the ESC or other criteria. Some of these studies may, however, not be applicable today because of the small cohorts or because they were published more than 10 years ago. Accordingly, relatively little is known about the validity of HF diagnosis in Sweden over time, or whether reported trends in HF epidemiology are real or the product of diagnosis by differing criteria. The aim of this study, therefore, was to validate the accuracy of a discharge or death diagnosis of HF in patients hospitalized between 2000 and 2012 at Sahlgrenska University Hospital, Gothenburg, Sweden according to the ESC HF guidelines.

Methods

In this context, a valid diagnosis is defined as relevant when in line with up-to-date diagnostic criteria.

Registers and selection of study cohort

It is mandatory to report all hospital discharge diagnoses in Sweden to the Swedish national inpatient register (IPR) that has been operating on a nation-wide basis since 1987. The present study is based on a random selection of all patients with a discharge diagnosis of HF between 2000 and 2012 at Sahlgrenska University Hospital, Gothenburg, Sweden. The hospital information technology support staff identified, via the digital record system Melior, all patients discharged or deceased during hospitalization with the code 150 (specific for HF) from the international classification of disease coding system, 10th revision (ICD-10), from the internal medicine or cardiology clinics, for a total of 27,517 patients. Using SAS version 9.3 (SAS Institute, Cary, NC, USA), a random independent sample of 1100 patients aged 20–100 at discharge or death during hospitalization was selected. In 550 patients, HF was a primary diagnosis, and in the other 550, it was a contributory diagnosis. The digital record system Melior was introduced in Gothenburg between 2000 and 2002, depending on hospital and clinic. Medical records of patients hospitalized before the introduction of Melior were retrieved from the hospital archives. Out of the 1100 patient records selected, a total of 135 were excluded for the following reasons: a scheduled procedure (n = 22); missing diagnosis, clinic other than internal medicine or cardiology, outside the selected age range, or missing digits in the personal identification number (n = 53); transfer to another hospital during the hospitalization (n = 12); severe dementia or other diagnoses where symptoms could not be validated (n = 11); and missing medical records (n = 37). Nine hundred and sixty-five patient records remained in the analysis (Figure 1).

This study conforms to the principles outlined in the Declaration of Helsinki and was approved by the Regional Ethical Review Board of the University of Gothenburg (registration number 2011-588/08/10).

Data collection

Information was registered in a form containing 65 variables. All written text from admission to discharge or death of the index hospitalization in patients with HF as primary diagnosis was studied, and whenever needed, data were accessed from earlier examinations and admissions. In patients with HF as a contributory diagnosis, the first recorded admission with HF was used for signs and symptoms, and prior examinations performed up until the index hospitalization were evaluated because this information was available to the diagnosing physician. Co-morbidities were recorded from the hospital admission notes and discharge ICD codes. A pilot study of 20 patient records showed that several patients had high serum creatinine values without a diagnosis of renal failure, and therefore, we added serum creatinine as a variable for the remaining 945 patients. Likewise, after the evaluation of records from patients with HF as a primary diagnosis, several cases of alcohol or drug abuse were noted, and a variable for this co-morbidity was added for the remaining 543 cases.

Electrocardiography

If several electrocardiograms (ECGs) were performed during the hospital stay, only the first was examined. ECG variables studied were rhythm, QRS duration, left bundle branch block, and pathological Q waves. ECG was considered to be pathological when at least one of the following abnormalities was present: rhythm other than sinus, QRS duration > 100 ms, or pathological Q waves. When original ECG records were not available, information in the admission notes was used. In cases where ECG or this information could not be found, it was marked as ‘not performed’.

Echocardiography

In patients with a primary diagnosis of HF, the echocardiography data from the most recent report during or before the index hospitalization were used. In patients with HF as a
contribute diagnosis, the echocardiography report with the most evident signs of HF was used. Distinct criteria for diastolic dysfunction were first mentioned in the guidelines in 2008. This was taken into consideration when validating the diagnosis of patients with suspected HF with preserved ejection fraction (HFpEF); when the report did not clearly state the presence of a diastolic dysfunction, the record was carefully examined by one or two experienced cardiologists to decide the validity of the diagnosis. A patient with HFpEF could thus be classified as definite HF even before the 2008 guidelines.

An echocardiography report fulfilling the ESC criteria for HF was considered objective evidence of HF. Furthermore, magnetic resonance imaging (MRI), left ventricular angiography, cardiac scintigraphy, and autopsy results were also considered objective evidence of HF when abnormal cardiac function data were reported. A patient who had not undergone any of the tests above and thus lacked confirmation of cardiac dysfunction but fulfilled all the other diagnostic criteria was listed under the category ‘probable’ (Table 1). A patient with normal echocardiography was registered as having undergone echocardiography but without objective evidence of cardiac dysfunction. If the echocardiography result was normal during the index hospitalization, the case was listed as ‘miscoded’.

Chest X-ray and/or computed tomography of the chest
Primarily, any chest X-ray or computed tomography of the chest performed during the hospitalization was used. If no chest X-ray or computed tomography of the chest was noted during the index hospitalization, any such diagnostic procedure within the 12 months prior to the index hospitalization that showed signs of HF was used. Findings considered to be HF-associated were pulmonary congestion, pulmonary redistribution, pleural fluid, and cardiomegaly.

Natriuretic peptides
N-terminal pro-B-type natriuretic peptide (NT-proBNP) or B-type natriuretic peptide (BNP) levels were recorded, if known, from the index hospitalization. If a value was missing, the highest previous measurement was used. The cut-off was set to 400 pg/mL for BNP and 2000 pg/mL for NT-proBNP.

Figure 1 Flowchart of patient selection.
Diagnostic classification

ESC guidelines for diagnosis and treatment of HF have been broadly implemented in Swedish health care programs. Erhardt and colleagues surveyed Swedish cardiologists and reported that 98% were aware of the ESC HF guidelines and 71% of these stated that they followed ESC HF guidelines closely, while 5% did not.\textsuperscript{24}

HF diagnosis was validated according to the ESC guidelines\textsuperscript{10–14} (Table 1) that were current at the time of hospitalization and as judged by a review board consisting of four medical students and three experienced cardiologists. A medical student together with one cardiologist made the primary validation. If consensus could not be reached, as happened in 19 cases, two other cardiologists separately read the records and thereafter made a decision together. Guidelines were estimated to have been implemented the year following publication. For example, the 2001 guidelines were used when validating patients between 2002 and the publication of the next version. Since the 2012 guidelines were published in July of 2012, we presumed that they did not come into practice until 2013 and were therefore not used in this study.

The ESC guidelines used for this validation varied over the years in order to reflect the clinical setting for the year of diagnosis, but the presence of symptoms and signs have been taken into account throughout. In the 1995 guidelines,\textsuperscript{10} apart from the two mandatory criteria (symptoms typical of HF and objective evidence of cardiac dysfunction), a positive response to HF treatment strengthened the diagnosis. In addition, the diagnosis of HF could be made ‘with some confidence’ if several typical signs (peripheral oedema, elevated jugular venous pressure, displaced apex beat, and a presence of a third heart sound) were present together with appropriate symptoms (breathlessness, ankle swelling, and fatigue). Positive findings on ECG and chest X-rays were supportive of the diagnosis. In the 2001 guidelines,\textsuperscript{11} natriuretic peptide levels were introduced as a tool to exclude HF, especially in untreated patients. In the 2005 guidelines,\textsuperscript{12} echocardiography was highlighted as the preferred objective method to confirm cardiac dysfunction. Here, for the first time, criteria for diagnosing diastolic dysfunction were presented. In all versions of the guidelines mentioned above (1995, 2001, and 2005) objective evidence of cardiac dysfunction was defined as cardiac dysfunction on imaging, preferably echocardiography.

The 2008 guidelines\textsuperscript{13} differed in several ways from guidance in the previous versions. Typical signs of HF were now a mandatory criterion. Furthermore, cardiomegaly on chest X-ray, a third heart sound, cardiac murmur, or elevated natriuretic peptide levels were considered objective evidence apart from echocardiography findings. A chest X-ray with pulmonary congestion strongly promoted the diagnosis.

Interobserver validation

A second validation of 20 randomly selected cases to test intraobserver accuracy yielded 89.5% congruence. One patient with a primary diagnosis of HF was validated as probable instead of miscoded, and one patient with HF in contributory position was validated as probable instead of definite.

Statistics

Descriptive statistics was used to present baseline characteristics and determine percentages, means, standard deviation (SD) or range, and interquartile range. For normally distributed variables, groups were compared using independent sample t-tests for continuous variables or Pearson’s $\chi^2$ for categorical variables. The Mann–Whitney U-test was used for variables that were not normally distributed. Analyses were conducted using the SPSS Advanced Statistics for Windows statistical package, version 22 (IBM SPSS, Armonk, NY, USA). Two-sided $P$-values $<0.05$ were considered statistically significant.

Table 1 Diagnostic assessments supporting or opposing the heart failure diagnosis from the different ESC guidelines used in the study

|                          | 1995 Supports if present/opposes if normal or absent | 2001 Supports if present/opposes if normal or absent | 2005 Supports if present/opposes if normal or absent | 2008 Supports if present/opposes if normal or absent |
|--------------------------|-----------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------|
| Appropriate symptoms     | ++++/---                                            | ++++/---                                            | ++++/---                                            | ++++/---                                            |
| Appropriate signs         | ++/-                                               | ++/-                                               | ++/-                                               | ++/-                                               |
| Response to treatment     | ++/---                                             | ++/---                                             | ++/---                                             | ++/---                                             |
| Pathological ECG          | /---                                               | /---                                               | /---                                               | /---                                               |
| Cardiac dysfunction on imaging | ++++/---                                      | ++++/---                                           | ++++/---                                           | ++++/---                                           |
| Chest X-ray              | +/-                                                | +/-                                                | +/-                                                | +/-                                                |
| Natriuretic peptides     | n/a                                                | +/ (if elevated)                                   | +/ (if elevated)                                   | +++ (if elevated)                                   |

Abbreviations: +/-, of some importance; ++/--, of particular/considerable importance; +++/---, of major importance; ECG, electrocardiogram; ESC, European society of cardiology.

*Required for definite diagnosis.

*Considered an objective evidence of cardiac dysfunction.
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Table 2 Overview of the different versions of ESC guidelines

| Year | Typical symptoms | Typical signs | Response to treatment | Pathological ECG | Cardiac dysfunction on imaging | Chest X-ray | Natriuretic peptides | Necessary for diagnosis |
|------|------------------|---------------|-----------------------|-----------------|--------------------------------|-------------|---------------------|------------------------|
| 1995 | Breathlessness, ankle swelling, and fatigue | Peripheral oedema, raised venous pressure, hepatomegaly, displaced apex beat, and third heart sound | Strengthens if present, opposes if absent | Usually on echocardiography | Primarily for detection of differential diagnosis, mildly strengthens if congestion and cardiomegaly, and mildly opposes if normal | Mildly strengthens if elevated, opposes if normal | Appropriate symptoms and cardiac dysfunction on imaging |
| 2001 | Breathlessness, ankle swelling, and fatigue | Peripheral oedema, raised venous pressure, hepatomegaly, displaced apex beat, and third heart sound | Strengthens if present, opposes if absent | Usually on echocardiography | Primarily for detection of differential diagnosis, mildly strengthens if congestion and cardiomegaly, and mildly opposes if normal | Mildly strengthens if elevated, opposes if normal | Appropriate symptoms and cardiac dysfunction on imaging |
| 2005 | Breathlessness, ankle swelling, and fatigue | Peripheral oedema, raised venous pressure, hepatomegaly, displaced apex beat, and third heart sound | Strengthens if present, opposes if absent | Usually on echocardiography | Primarily for detection of differential diagnosis, mildly strengthens if congestion and cardiomegaly, and mildly opposes if normal | Mildly strengthens if elevated, opposes if normal | Appropriate symptoms and cardiac dysfunction on imaging |
| 2008 | Breathlessness, ankle swelling, and fatigue | Tachycardia, tachypnoea, pulmonary rales, pleural effusion, raised jugular venous pressure, peripheral oedema, hepatomegaly, cardiac murmurs, and third heart sound | Strengthens if present, opposes if absent | Usually on echocardiography | Cardiomegaly considered objective evidence of structural abnormality of the heart at rest | Elevation considered objective evidence of structural abnormality of the heart at rest | Appropriate symptoms, appropriate signs (in bold) and objective evidence of cardiac dysfunction not limited to cardiac imaging but including cardiomegaly, third heart sound, cardiac murmurs, and raised natriuretic peptides |

Abbreviations: ECG, electrocardiogram; ESC, European Society of Cardiology.

Results

Study population

We used records from 965 patients (50.5% women), with a mean age of 78.7 (SD: 11.2) and median age of 81 (range: 20–100) years at diagnosis. In 55.4% of patients, HF was the primary diagnosis, and 80.5% of patients were treated at an internal medicine ward (Table 3).

Validity

In total, 601 (62.3%) cases were classified as definite, 310 (32.1%) as probable, and 54 (5.6%) as miscoded. Thus, the diagnosis was definite or probable in 94.4% of cases. The patients were divided into four groups, based on the ESC guidelines (1995, 2001, 2005, and 2008) that were in effect during the index hospitalization: 2000–01, 2002–05, 2006–08, and 2009–12 containing 211 (21.8%), 328 (34.0%), 179 (18.5%), and 247 (25.6%) numbers of patients, respectively (1995, 2001, 2005, and 2008). The proportion of definite cases constituted 56.9%, 54.5%, 54.7%, and 82.6% of cases in the four groups, while 6.2%, 8.2%, 5.0%, and 2.0% of cases in the four groups were miscoded under the guidelines. (Figure 2). The majority of miscoded cases either had a malignancy or died from sudden cardiac arrest, although the format of this study did not allow for details in these cases.

Co-morbidities

The most frequent co-morbidities and/or possible etiologic factors were ischemic heart disease, atrial fibrillation/flutter, and hypertension (Table 4). Cardiomyopathy was present in 4.7% of cases. Abuse of alcohol or other substances was noted in 8.3% of the 543 cases where this was evaluated. Renal failure had been diagnosed in 15.9% of cases, whereas an elevated creatinine level was observed in 212 of the 377 cases where this information was available (56.2%). Serum creatinine values were only available in 39.9% of cases because blood test results were not available for patients diagnosed before the medical records were digitized. No significant difference was found when comparing the validity between the whole study population and the subgroups with various co-morbidities, except that the group of cases classified as definite HF had significantly fewer diagnoses of thyroid disease (6.8% vs. 12.9%) and significantly higher rates of renal failure (17.6% vs. 11.9%) and elevated creatinine.
Figure 2. Validity of heart failure diagnosis between 2000 and 2012. The four periods indicated in the figure were validated by the guidelines of the European Society of Cardiology published in 1995, 2001, 2005, and 2008, respectively. Each diagnosis was validated as definite, probable, or miscoded.

(57.4% vs. 52.8%) than the group of cases classified as probable HF.

Clinical signs and symptoms

The most frequent symptom was dyspnoea (83.3%), followed by fatigue (31.4%) and ankle swelling (31.0%). A wide range of signs associated with HF was present, with the most common being pulmonary rales (61.5%) and peripheral oedema (48%). The group of cases classified as definite exhibited more dyspnoea, orthopnoea, and weight gain than the group of cases classified as probable. Both groups exhibited more dyspnoea, fatigue, tachycardia, and tachypnoea than the group of miscoded cases (E-Table S1).

Diagnostic tools

Echocardiography was performed in 96.7% of patients in the definite-HF group, 34.2% of patients in the probable-HF group, and 57.4% of the patients in the miscoded-cases group. Echocardiography was performed more frequently between 2009 and 2012 (85.0% of cases) than in earlier years (68.7%–71.9%) (Table 5). A missing or incomplete echocardiography report was the most common reason for probable cases not being classified as definite.

There was no significant difference in pathological ECG results between the definite (96.6%) and probable (96%) cases, but these were less frequent in miscoded cases (79.2%). A chest X-ray was performed in 93.5% of cases. Congestion was more often found in definite (71.5%) and probable (73.0%) cases than in miscoded cases (38.6%) (Table 3).

MRI, left ventricular angiography, or scintigraphy were only performed in 10 cases. Objective evidence of HF was found by autopsy in two cases and by MRI in one case.

Discussion

In this study, we validated HF diagnoses in 965 patients according to the ESC guidelines over a period of 12 years. Only 5.6% of cases had been miscoded, and the proportion of miscoded cases decreased over time to 2.0%, while the proportion of cases with definite HF increased over time to 83.0%. Overall, the diagnosis of HF was considered definite in 62.3% of cases and probable in 32.1% of cases.

Ingelsson and colleagues investigated the validity of HF diagnosis according to ESC criteria in middle-aged men in Sweden from 1995 onwards. Hospital diagnoses made between 1976 and 2001 were evaluated in 321 men aged 51–81 years. The study reported a validity of 86% and 91% for patients treated at either an internal medicine or cardiology clinic, respectively, with a primary or contributory diagnosis of HF. The validity among patients with HF as primary diagnosis was 95%, regardless of the type of clinic. As 51% of the patients were diagnosed without an echocardiography, Ingelsson and colleagues instead used a pathological ECG or chest X-ray as objective evidence for HF. However, echocardiography would have been required according to the relevant guidelines.

In our study, diagnoses validated as definite met the mandatory diagnostic criteria of the ESC. The 1995, 2001, and 2005 guidelines defined these criteria as symptoms typical of HF together with objective evidence of cardiac dysfunction. In the 2008 ESC guidelines, a third criterion was added: clinical signs characteristic of HF. A probable diagnosis of HF would typically fulfil the criteria for symptoms and clinical signs (2008), often presented together with a pathological ECG or an abnormal chest X-ray but lacking an objective evidence of cardiac dysfunction. Miscoded diagnoses primarily presented with symptoms typical of HF but without clinical signs, X-ray findings associated with HF, abnormal echocardiography or other comparable measure of cardiac function.

The group classified as probable displayed the classical signs and symptoms of HF, often supported by pathology from chest X-rays and ECG, but echocardiography was only performed in 34.2% of cases, whereas in the group classified as definite, echocardiography was performed in 96.7% of cases. This figure was not 100% because echocardiography was not mandatory for the diagnosis of HF in the 2008 guidelines. In diagnoses made earlier, objective evidence of HF was also found by autopsy in two cases and by MRI in one case.
|                                | Total (n = 965) | Definite HF (n = 601) | Probable HF (n = 310) | Miscoded HF (n = 54) | P-value definite vs. probable | P-value definite vs. miscoded | P-value probable vs. miscoded |
|--------------------------------|----------------|-------------------|---------------------|---------------------|-------------------------------|-----------------------------|-----------------------------|
| Age (years), mean (SD)        | 78.7 (11.2)    | 76.9 (11.4)       | 81.9 (9.6)          | 81.1 (12)           | 0.000                         | 0.009                       | 0.615                       |
| Female sex                    | 487 (50.5)     | 273 (45.4)        | 186 (60)            | 28 (51.9)           | 0.000                         | 0.364                       | 0.262                       |
| Diagnostic position           |                |                   |                     |                     |                               |                             |                             |
| Primary                       | 535 (55.4)     | 350 (58.2)        | 165 (53.2)          | 20 (37)             | 0.137                         | 0.003                       | 0.028                       |
| Contributory                  | 430 (44.6)     | 251 (41.8)        | 145 (46.8)          | 34 (63)             |                               |                             |                             |
| Echocardiography performed    | 718 (74.4)     | 581 (96.7)        | 106 (34.2)          | 31 (57.4)           | 0.000                         | 0.000                       | 0.001                       |
| Ejection fraction (SD)        | 41.9 (15.3) (n = 681) | 39.5 (14.7) (n = 560) | 52.0 (13.6) (n = 95) | 56.7 (8.1) (n = 26) | 0.000                         | 0.000                       | 0.029                       |
| Pathologic ECGb               | 850 (95.5) (n = 890) | 547 (96.6) (n = 566) | 265 (96.0) (n = 276) | 38 (79.2) (n = 48) | 0.644                         | 0.000                       | 0.000                       |
| Congestion on X-ray           | 635 (70.4) (n = 902) | 402 (71.5) (n = 562) | 216 (73) (n = 296) | 17 (38.6) (n = 44) | 0.654                         | 0.000                       | 0.000                       |
| Positive response to treatment| 622 (92.8) (n = 669) | 408 (93.8) (n = 435) | 195 (92.4) (n = 211) | 19 (82.6) (n = 23) | 0.352                         | 0.000                       | 0.001                       |
| Hospitalac:                   |                |                   |                     |                     | 0.000                         | 0.047                       | 0.850                       |
| Sahlgrenska hospital          | 353 (36.6)     | 184 (30.6)        | 144 (46.5)          | 25 (46.3)           |                               |                             |                             |
| Mölndal hospital              | 194 (20.1)     | 129 (21.5)        | 54 (17.4)           | 11 (20.4)           |                               |                             |                             |
| Östra hospital                | 418 (43.3)     | 288 (47.9)        | 112 (36.1)          | 18 (33.3)           |                               |                             |                             |
| Specialityc:                  |                |                   |                     |                     | 0.000                         | 0.028                       | 0.915                       |
| Internal medicine clinic      | 777 (80.5)     | 455 (75.7)        | 274 (88.4)          | 48 (88.9)           |                               |                             |                             |
| Cardiology clinic             | 188 (19.5)     | 146 (24.3)        | 36 (11.6)           | 6 (11.1)            |                               |                             |                             |

All values are n (%). Abbreviations: n, total number of subjects; HF, heart failure; ESC, European Society of Cardiology; NT-proBNP, N-terminal pro brain natriuretic peptide; ECG, electrocardiogram; SD, standard deviation; IQR, interquartile range. When the total value of a variable was less than five no comparison between the groups was made because of statistical reasons.

*P-values for all subcategories.

bIn 19 cases, the ECG could not be located and the journal text was not specific enough to confirm or rule out any pathology so these patients were not included in the analysis.

cThe Sahlgrenska University Hospital is constituted by three different hospitals.
The ejection fraction was lower in the group classified as definite as in the group classified as probable, perhaps because the latter included more cases with HFrEF. Knowledge of HFrEF has increased over the past 15 years, and we now know that this category comprises more women and elderly patients than HF with reduced ejection fraction (HFrEF),\textsuperscript{25} as was the case in the group classified as probable in this study. In addition, there was no significant difference in the rates of pathologic ECG, congestion observed in chest X-rays, or positive response to treatment between the two groups. Hence, we believe that the vast majority of cases in the group classified as probable did have HF. Ingelsson and colleagues defined cases comparable with those in our probable group as definite.\textsuperscript{36}

The use of echocardiography was fairly consistent between 2000 and 2008, but increased in later years. High use of echocardiography in the miscoded group indicates the value of this tool in ruling out HF. The lowest rate of echocardiography use was found in the group classified as probable, which would be expected because of the requirement for objective evidence of cardiac dysfunction for a definite diagnosis. In the earliest period studied, some HF cases could have been missed even if echocardiography had been performed, as there were no diagnostic criteria for HFrEF. We found that diagnoses made according to the 2008 ESC guidelines were more often considered definite and with fewer miscoded cases than diagnoses validated according to previous versions of the guidelines. This may be attributable to the wider definition of ‘objective evidence’ for HF.

Today, echocardiography is widely available and at a relatively low cost,\textsuperscript{25} although it requires specialized knowledge and is therefore user-dependent.\textsuperscript{26} However, far from all patients with a diagnosis of HF made outside a hospital are diagnosed by means of echocardiography.\textsuperscript{20} Furthermore, Agvall and Dahlström found that in a primary care setting, the diagnosis of HF was not generally based on echocardiography but on a combination of clinical signs, symptoms, and less-accurate methods such as an ECG and chest X-ray.\textsuperscript{27}

HF, ideally, should be diagnosed along with the underlying cause of this disorder. This is not always the case, however, and the assignment of HF as a principal or contributory cause of hospitalization is not consistent. Therefore, we validated the diagnosis of HF in either diagnostic position. There were more definite cases from the cardiology wards than from the internal medicine wards, in accordance with findings from previous studies.\textsuperscript{16,21} When HF was the primary diagnosis, 65.4% of cases were classified as definite, while only 58.3% of cases were classified as definite when HF was diagnosed as the contributory cause of hospitalization.

### Clinical and public health implications of these findings

Swedish hospital discharge data have been increasingly used in the study of HF and may provide information that

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### Table 4 Co-morbidities according to validity of diagnosis

| Co-morbidity                        | Total (n = 965) | Definite HF (n = 601) | Probable HF (n = 310) | Miscoded HF (n = 54) |
|------------------------------------|-----------------|-----------------------|-----------------------|---------------------|
| Ischaemic heart disease            | 484 (50.2)      | 316 (47.4)            | 145 (46.8)            | 23 (42.6)           |
| Diabetes mellitus                  | 217 (22.5)      | 144 (24)              | 66 (21.3)             | 7 (13)              |
| Hypertension                       | 449 (46.5)      | 277 (46.1)            | 142 (45.8)            | 30 (55.6)           |
| Thyroid disease                    | 85 (8.8)        | 41 (6.8)              | 40 (12.9)             | 4 (7.4)             |
| Asthma/COPD                        | 159 (16.5)      | 103 (17.1)            | 45 (14.5)             | 11 (20.4)           |
| Renal failure                      | 153 (15.9)      | 106 (17.6)            | 37 (11.9)             | 10 (18.5)           |
| Elevated creatinine\textsuperscript{a} | 212 (56.2) (n = 377) | 146 (57.4) (n = 254) | 56 (52.8) (n = 106) | 10 (58.8) (n = 17) |
| Cardiomyopathy                     | 45 (4.7)        | 43 (7.2)              | 2 (0.6)               | 0                   |
| Atrial fibrillation/flutter         | 483 (50.1)      | 308 (51.2)            | 151 (48.7)            | 24 (44.4)           |
| Systemic inflammatory disease      | 73 (7.6)        | 42 (7)                | 26 (8.4)              | 5 (9.3)             |
| Alcohol, drugs                     | 45 (8.3) (n = 543) | 33 (9.6) (n = 344) | 8 (4.9) (n = 163) | 4 (11.1) (n = 36) |

All values are n (%). Abbreviations: n, total number of subjects; HF, heart failure; COPD, chronic obstructive pulmonary disease. When the total value of a variable was less than five no comparison between the groups was made because of statistical reasons.

\textsuperscript{a}Creatinine $\geq$ 120 $\mu$mol/L.

### Table 5 Presence of an echocardiographic examination and relation to validity of the diagnosis

| Diagnosis year | Total (n = 965) | Definite HF (n = 601) | Probable HF (n = 310) | Miscoded HF (n = 54) |
|----------------|-----------------|-----------------------|-----------------------|---------------------|
| 2000–2001      | 145 (68.7) (n = 211) | 118 (98.3) (n = 120) | 21 (26.9) (n = 78) | 6 (46.2) (n = 13) |
| 2002–2005      | 236 (71.9) (n = 328) | 178 (99.4) (n = 179) | 44 (36.1) (n = 122) | 14 (51.9) (n = 27) |
| 2006–2008      | 127 (70.9) (n = 179) | 98 (100) (n = 98) | 22 (30.6) (n = 72) | 7 (77.8) (n = 9) |
| 2009–2012      | 210 (85) (n = 247) | 187 (91.7) (n = 204) | 19 (50) (n = 38) | 4 (80) (n = 5) |

All values are n (%). Abbreviations: n, total number of subjects; HF, heart failure.
cannot be provided in clinical or population studies. For example, we found an unexpected increase in HF incidence in young Swedish adults,4 a group where HF is rare and where data from two decades from an entire nation were needed to convincingly demonstrate this. We were then able to establish an exceptionally strong link between obesity in 1.6 million adolescent men and early HF.28 Rising rates of obesity in the young may explain this increase, but in order to draw conclusions from this potentially important finding, the diagnoses on which this supposition rests must obviously be validated. We have also been able to demonstrate a lack of improvement in survival in HF patients in recent years.4 Accordingly, the present study is clinically relevant in that register data will allow for studies of HF that can only be carried out using very large populations, as exemplified here, and is also relevant from a public health perspective.

Limitations

This study was a retrospective review of existing medical records with inherent limitations. We were confined to data already collected, and in some cases, data were missing. Even with a structured evaluation using the relevant ESC guidelines, clinical judgment of diagnosis validity was required from medical students and experienced cardiologists. In contested cases, such as all miscoded ones, a further validation by two other cardiologists was performed. The interobserver validity in a sampling of 20 cases was high.

Conclusions

This study found a high validity of HF diagnosis at internal medicine and cardiology wards in a university hospital over a period of 12 years using the diagnostic criteria of the ESC that were current during the year of hospitalization. The study findings indicate that clinicians at the cardiology and internal medicine wards of the hospitals sampled were experienced enough to make fairly accurate diagnoses on heart failure according to ESC guidelines present at the time for diagnosis and thus strengthen future epidemiological research using the Swedish national hospital discharge register.

Conflicts of interest

Dr Schaufelberger has received research grants to her institution and served on the speakers’ bureau or received consulting fees from Pfizer, Bayer AG, and Novartis. All other authors have nothing to declare.

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