The validity of the diagnosis of heart failure (I50.0-I50.9) in the Danish National Patient Register

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ABSTRACT

INTRODUCTION: National discharge registers are important and cost-effective data sources for administrative and research purposes, but their value depends much on the validity of the registered data. The objective of this study was to assess the validity of heart failure (HF) diagnoses (ICD10: I50.0-I50.9) in the Danish National Patient Register (DNPR).

METHODS: We reviewed medical records from a random sample of 500 patients with either a primary or a secondary discharge diagnosis of HF registered in the DNPR from any department in Northern Denmark in 2007. We noted symptoms, objective signs, diagnostic imaging and biomarkers and used the European Society of Cardiology definition of HF to categorise patients into definite, probable or non-verified HF.

RESULTS: We classified 305 patients as having definite HF and 113 patients as having probable HF. The remaining cases were classified as non-verified HF. Thus, the positive predictive value (PPV) for definite and probable HF was 83.6% (95% confidence interval (CI): 80.1-86.7%).

THE PPV INCREASED TO 88.0% (95% CI: 84.4-91.0%) when we restricted analyses to primary diagnoses and to 95.2% (95% CI: 89.2-98.4%) when we restricted analyses to HF diagnoses established at cardiology units.

CONCLUSIONS: The HF diagnoses (I50.0-I50.9) in the DNPR should be used with caution if validation is not possible. However, restricting analyses to patients registered with a primary diagnosis of HF or patients discharged from cardiology units may be a useful alternative in population-based studies.

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Heart failure (HF) is a complex clinical entity that may develop with the progression of many cardiovascular diseases. HF affects approximately 1-2% of the adult population in Western countries, and numbers are growing with an aging population, reaching over 10% in patients aged over 70 years [1].

Diagnosing HF may be challenging, particularly in elderly or obese patients with comorbidities, or when cardiac imaging tests show preserved left ventricular ejection fraction (LVEF) [2-4]. An estimated 22-73% of patients with HF have preserved LVEF (HFpEF) [1], and the prognosis of HFpEF seems to be as poor as for HF with reduced LVEF [4-6].

Epidemiological studies based on national discharge registers are cost-effective data sources that allow studies on large study populations, but the usability of these registers is highly dependent on the validity of the registered data. Several studies from Europe have shown lower positive predictive values (PPV) of HF diagnoses in hospital discharge registries compared with other cardiovascular diseases [7-9] and denoted a marked underestimation of events related to HF in national discharge registers [2, 7, 10-13]. Consecutive assessment of the validity of discharge diagnoses is important when defining endpoints and interpreting the results of epidemiological studies.

The aim of this study was to assess the PPV of HF discharge diagnoses registered in the Danish National Patient Register (DNPR).

METHODS

Study population

Since 1977, all hospitals in Denmark have been obliged to report discharge diagnoses to the DNPR. All citizens and residents living in Denmark are provided with a unique ten-digit identification number, which enables patient identification by record linkage between nationwide registers.

We used the DNPR to identify patients registered with either a primary or a secondary diagnosis of HF (International Classification of Diseases, Version 10 (ICD-10): I50.0-I50.9), who were discharged between 1 January 2007 and 31 December 2007 from any department (wards, outpatient clinics and emergency departments) from all hospitals in the Northern Denmark Region, which counts almost 10% of the Danish population. Only the first registered discharge diagnosis of incident or recurrent HF within this year was considered.

This study was approved by the Danish Data Protection Agency (R. no.: 2013-41-1650).

Identification of cases and diagnostic classification

One of three reviewers (SMH, KSA, CSB) scrutinised the medical records of 500 randomly selected patients registered with HF, including 400 primary diagnoses and 100 secondary diagnoses (**Figure 1**). Data collection was

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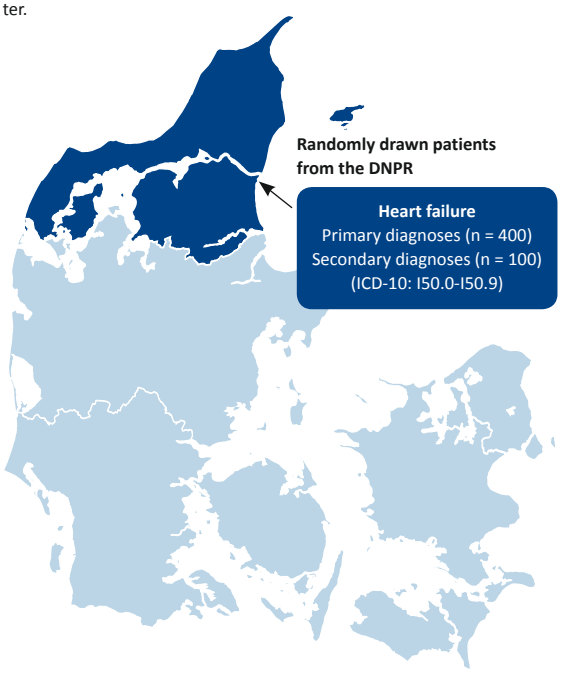
FIGURE 1

Patients registered with a discharge diagnosis of heart failure in Northern Denmark were randomly drawn from the Danish National Patient Register.



DNPR = Danish National Patient Register; ICD-10 = International Classification of Diseases, Version 10.
Source: Bigstock.

based on strictly defined criteria and performed by thorough and systematic review of discharge summaries and medical records corresponding to the discharge diagnosis and the discharge date contained in the DNPR. Minor mismatches were accepted in the registered date of admission or discharge in the register and medical records. Results of blood tests, chest X-ray and echocardiography descriptions were collected accordingly. If echocardiography descriptions were missing in the medical records, we investigated an echocardiography database for further information (EchoPAC PC, GE Medical Systems).

Cases with uncertainty were discussed within the group and with a specialist in cardiology (AMJ), and diagnoses were made according to consensus.

We defined HF based on the European Society of Cardiology (ESC) Guidelines that were valid at the time of registration of the diagnoses in the DNPR, and we registered whether the patients had typical symptoms, signs and objective evidence of structural or functional cardiac dysfunction at rest [14].

Patients were categorised into definite, probable or non-verified HF (**Table 1**).

Statistical analysis

We calculated PPV with corresponding 95% Clopper-Pearson binomial confidence intervals (CI). The PPV were calculated as the proportions of validated cases divided by the total number of patients registered with a HF diagnosis.

We stratified the data based on gender, type of diagnosis (primary versus secondary), type of department and whether or not echocardiography had been performed.

All data analyses were conducted using STATA (version 11, StataCorp LP, College Station, USA).

Trial registration: not relevant.

RESULTS

Out of 500 patients included in the study, 53% were males and the median age was 77 years (interquartile range: 68- 84). A total of 105 (21%) patients were discharged from cardiology units, and 370 (74%) patients were discharged from other internal medicine units. The frequency of discharge diagnoses of HF from particular wards and outpatient clinics is presented in **Table 2**.

In all, 305 patients (61.0%) fulfilled the criteria of definite HF and another 113 (22.6%) patients were classified as probable HF cases. The remaining 82 (16.4%) cases were classified as non-verified HF; of these, 80 patients had at least one sign and/or one symptom typical for HF but no objective evidence of cardiac dysfunction, and another two patients had some objective evidence of cardiac dysfunction other than echocardiography, but no registered signs and/or symptoms of HF. Thus, the PPV for definite and probable HF was 83.6% (95% CI: 80.1-86.7%) (**Table 3**).

A total of 380 patients (76%) underwent echocardiography, and 305 of them (80.3%) had an abnormality on their echocardiograms. Fifty patients (13.2%) were classified as having probable HF with preserved LVEF, as they had a written report stating preserved LVEF, but the measurements of diastolic function were not stated in echocardiography descriptions. Thus, the PPV for the HF diagnosis among patients who underwent echocardiography was 93.4% (95% CI: 90.4-95.7%).

When stratifying the data based on type of diagnosis, we found PPV of 88.0% (95% CI: 84.4-91.0%) for a primary diagnosis and 66.0% (95% CI: 55.8-75.2%) for a secondary diagnosis (Table 3).

When stratifying for type of department, we found PPV of 95.2% (95% CI: 89.2-98.4%), 82.9% (95% CI: 78.7-86.6%) and 46.2% (95% CI: 26.6-66.6%) for cardiology, internal medicine and other departments, respectively. In gender-specific analyses, we found PPV for HF of 85.4% (95% CI: 80.6-89.4%) among men and of 81.5% (95% CI: 76.0-86.3%) among women (Table 3).

DISCUSSION

We evaluated the validity of discharge diagnoses of HF (I50.0-I50.9) in the DNPR using review of medical records as reference. The overall PPV for definite and probable HF was 83.6%. The PPV were slightly higher for primary diagnoses (88.0%) and significantly higher for diagnoses established at cardiology units (95.2%).

Previous validation studies from Denmark [9-11, 15], Sweden [12], Great Britain [13] and Portugal [2] have reported PPV of HF diagnoses in the range 76-100%.

Mard & Nielsen [11] investigated the validity of HF diagnoses obtained from a cardiac care unit of a university hospital in Copenhagen and found a PPV of 84%. Ingelsson et al [12] examined the PPV of HF among 317 Swedish men and found a PPV of definite HF of 82%. The authors observed a marked increase in the PPV of HF to 95% when only primary diagnoses of HF were considered and to 91% when patients were discharged from a cardiology unit.

Similar findings were reported by Kümler et al [10], who assessed the accuracy of HF diagnoses in the DNPR in the late nineties. The authors evaluated a great number of patients who were consecutively admitted to all departments within one hospital in Copenhagen and found a PPV of HF diagnoses of 81%. Of note, the researchers reported a sensitivity of HF diagnoses of 29%, which indicated a large underestimation of the true number of cases.

Substantial underestimation of the burden of HF has also been reported by Khand et al [13], who evaluated the accuracy of HF diagnoses in patients discharged with either a diagnosis of HF or atrial fibrillation. The authors concluded that the examined discharge codes were relatively valid with PPV ranging from 77% to 87%, but may substantially underestimate admissions related to HF in the United Kingdom. Our study design does not allow us to assess such important measures of validity as sensitivity, specificity or negative predictive values.

A Danish study by Thygesen et al [15] examined the PPV of 50 discharge diagnoses of HF registered in the DNPR from the Northern Denmark Region within a ten-year study period (1998-2007) and found a PPV of 100%. However, the authors used descriptions in the discharge summaries as a reference, and review of medical records for discharge codes was only performed if information in the discharge summary was not available; thus, the study did not consider whether the patients fulfilled the diagnostic criteria of HF.

Sundbøll et al [9] investigated PPV of 100 randomly chosen first-time discharge diagnoses of HF and several other cardiovascular diagnoses registered in the DNPR between 2010 and 2012 from the Central Denmark Region, using review of medical records as reference.

TABLE 1

Classification of the accuracy of the heart failure diagnosis[a].

Classification	Description
Definite HF	≥ 1 typical symptom[b] of HF and/or ≥ 1 typical sign[c], and abnormality on echocardiogram[d] *or* Abnormality on echocardiogramd with or without reported symptoms[b] and signs[c] of HF
Probable HF	0 echocardiography examination at the time of diagnosis or missing description of diastolic function and ≥ 1 other objective piece of evidence of cardiac dysfunction[e] and ≥ 1 symptom[b] and/or ≥ 1 sign[c] indicating HF
Non-verified HF	Patients who did not meet the above-mentioned criteria and for whom information was insufficient

BNP = brain natriuretic peptide; ESC = European Society of Cardiology; HF = heart failure; NT-proBNP = N-terminal pro-brain natriuretic peptide.
a) Based on [14].
b) Symptoms of HF: breathlessness, fatigue, tiredness, ankle swelling.
c) Signs of HF: tachycardia, tachypnoea, pulmonary rales, pleural effusion, raised jugular venous pressure, peripheral oedema, hepatomegaly.
d) Abnormailty on echocardiogram: written report stating LVEF < 45%, diastolic dysfunction with increased filling pressure, moderate-severe valve disease, pulmonary hypertension.
e) Other objective evidence of cardiac dysfunction: cardiomegaly on chest X-ray, elevated concentrations of BNP > 400 pg/ml or NT-proBNP > 2,000 pg/ml, cardiac murmurs, 3rd heart sound.

TABLE 2

Frequency of discharges with heart failure diagnosis from particular wards and outpatient clinics.

Type of unit	Discharges, n (%)
Cardiology ward	103 (20.6)
Cardiology outpatient clinic	2 (0.4)
Medical ward	347 (69.4)
Medical outpatient clinic	23 (4.6)
Emergency department	2 (0.4)
Oncology ward	1 (0.2)
Obstetrics and gynaecology ward	2 (0.4)
Surgical ward	14 (2.8)
Orthopaedic surgery ward	5 (1.0)
Psychiatric ward	1 (0.2)
Total	500 (100)

They found a PPV of HF diagnoses of 76%, whereas markedly higher PPV were seen for several other cardiovascular diseases. However, the authors have not presented the diagnostic criteria used to confirm the diagnoses and have not specified how patients with missing information at the time of the diagnosis were evaluated.

The findings by Sundbøl et al [9] together with other previous studies reporting lower PPV of HF diagnoses compared with other cardiovascular diseases, such as acute myocardial infarction [7, 16] or stroke [8], may reflect the complex nature and definition of HF, which includes several non-specific signs and symptoms that may be challenging to identify in clinical practice. Therefore, ESC experts have recommended echocardiographic assessment of cardiac function in every patient with a clinical suspicion of HF [1, 14]. Some further diffi-

TABLE 3

Positive predictive values of heart failure diagnoses in the Danish National Patient Register.

Discharge diagnoses	Verified heart failure[a] n	PPV (95% CI)	Non-verified heart failure, n	Total, n
Gender				
Men	228	85.4 (80.6-89.4)	39	267
Women	190	81.5 (76.0-86.3)	43	233
Diagnosis				
Primary	352	88.0 (84.4-91.0)	48	400
Secondary	66	66.0 (55.8-75.2)	34	100
Units				
Cardiology	100	95.2 (89.2-98.4)	5	105
Internal medicine	306	82.9 (78.7-86.6)	63	369
Other	12	46.2 (26.6-66.6)	14	26
All discharge diagnoses	418	83.6 (80.1-86.7)	82	500

CI = confidence interval; PPV = positive predictive value.
a) Definite and probable heart failure.
b) Included discharges from surgical wards, orthopaedic surgery wards, emergency departments, an oncology ward, an obstetrics and gynaecology ward and a psychiatric ward.

culties arise in symptomatic patients with preserved LVEF. Grading of diastolic dysfunction is demanding, especially in patients with coexisting atrial fibrillation or mitral valve stenosis.

In the present study, echocardiography was performed in 76% of all patients. Consequently, in the remaining cases, the diagnosis was based on the clinical presentation and other imaging modalities or blood tests. Previous studies have reported echocardiographic assessment of cardiac function in 49-86.7% of cases [2, 12, 13].

Strengths and limitations

The present study has some strengths and limitations that warrant consideration. We investigated the validity of discharge diagnoses in routine clinical practice, which reflects authentic diagnostic difficulties. The observed study population included patients of both genders admitted to several hospitals in the North Denmark Region. Furthermore, we examined the accuracy of the diagnoses using the most recent ICD codes (ICD-10).

As in most validation studies, we used review of medical records as reference. Consequently, classification of cases depended highly on the quality of the data registered in the medical records, which varied significantly. Inadequate or missing data may have led to misclassification of true cases into non-verified HF and an underestimation of the observed PPV. Moreover, most medical records were evaluated by a single reviewer. However, data collection was based on strictly defined criteria, which may have limited errors due to any subjective judgements about symptoms, signs and other diagnostic findings. Another limitation was insufficiently documented echocardiographic examinations. We noticed that echocardiography focused primarily on systolic dysfunction and heart valve abnormalities, and measurements of diastolic function were not routinely reported. Moreover, the definition of HF, guidelines and thus medical practice may have influenced the validity of HF diagnoses after this study was conducted.

In accordance with several previous studies [10, 17], we limited potential cases of HF to patients registered with ICD-10 codes ranging from I50.0-I50.9. Thus, we did not include patients registered with hypertensive heart disease with HF (I11.0), hypertensive heart and renal disease with HF (I13.0), hypertensive heart and renal disease with both HF and renal disease (I13.2) or cardiomyopathies (I42.0 and I42.6-9). However, we believe that the discharge codes I50.0-I50.9 cover the vast majority of all ICD-10 codes describing HF [18].

Furthermore, we included both patients with incident and recurrent HF. As previous studies [9] have shown that PPV may vary within these two groups, all validations in the current study were based on the same strictly defined diagnostic criteria of HF according to relevant guidelines [14], which may have limited potential errors. Also, we only considered patients admitted to hospitals in one region of Denmark. However, we do not expect appreciable differences in coding errors or significant differences in the validity of registered diagnoses across the Danish regions.

CONCLUSIONS

In conclusion, the HF diagnoses (I50.0- I50.9) in the DNPR should be used with caution if validation is not possible. However, the observed overall PPV of 83% is moderately high and may be acceptable for some studies. Restricting analyses to patients registered with a primary diagnosis of HF or patients discharged from cardiology units may be a useful alternative in population-based studies if higher PPV of HF are needed.

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