

Supplementary Online Content

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eAppendix 1: Approach used to define disease categories for causes of deaths and hospitalizations

The CPRD data used in this study provides causes of death and hospitalizations in the form of clinical codes from the ICD-10 (International Classification of Diseases 10th edition) system. We sought to categorize causes of death and hospitalizations into a set of unique and clinically meaningful disease categories. For that purpose, we used the following approach, which we applied to deaths and hospitalizations separately: (i) As a starting point, categories were defined as each code's overarching ICD chapter (n = 22); (ii) Chapters that presented similarities for the purpose of this study were grouped together (e.g. ICD chapters "Injury, poisoning and certain other consequences of external causes" and "External causes of morbidity and mortality" were grouped together and categorized as "Injuries"); (iii) Groups of conditions that, in 2013, represented at least 2% of deaths (for the categorization of causes of deaths) or either 2% of deaths or hospitalizations (for the categorization of causes of hospitalizations), e.g. kidney diseases or infections, were defined as independent categories; (iv) Any remaining category that represented less than 2% of deaths/hospitalizations in itself was classified as "other". In the UK, guidance for completing medical certificates states that heart failure is not a cause but a mode of death and discourages doctors from recording heart failure as the underlying cause of death.^{1,2} Therefore, heart failure was defined as an individual disease category for hospitalizations, yet not for deaths.

eAppendix 2: Baseline variables

We extracted the most recent measurement of baseline characteristics recorded in patients primary care record within two years prior to incident heart failure diagnosis - these included systolic and diastolic blood pressure, smoking status, and body-mass index (BMI). BMI was categorized as underweight (<18.5 kg/m²), normal (18.5–24.9 kg/m²), overweight (25–29.9 kg/m²), obese (30–34.9 kg/m²), and severely obese (≥35 kg/m²).

We further report the care setting in which heart failure was first diagnosed. Diagnoses recorded during a hospital admission were further categorized based on whether heart failure was listed in primary or secondary diagnostic position. Diagnoses first recorded in primary care are likely to reflect both outpatient consultations by specialists and direct diagnoses by general practitioners.

To describe co-morbidities, we selected 17 common chronic conditions (anemia, asthma, atrial fibrillation, cancer, chronic kidney disease, chronic obstructive pulmonary disease, dementia, depression, diabetes, dyslipidemia, hypertension, ischemic heart disease, obesity, osteoarthritis, peripheral arterial disease, stroke, thyroid disease). Diagnosis code lists for the extraction of each condition were adapted from the CALIBER code repository.³

To describe socioeconomic status, we used the Index of Multiple Deprivation (IMD) 2015 quintile,⁴ a composite measure of relative deprivation at a small area level, ranked in ascending order of deprivation score and grouped in equal fifths.

Ethnicity is reported as recorded in patient's electronic health record. When ethnicity differed between primary and secondary care records, secondary care data was used. To assist readability, ethnicity was grouped into two categories, 'white' and 'other'.

Baseline characteristics are presented as frequencies (%) for categorical data, medians and interquartile range (IQR) for non-normally distributed continuous data, or means and standard deviation (SD) for normally distributed continuous data.

eAppendix 3: Validity of diagnoses recorded in electronic health record databases

Research using electronic health records databases is reliant on the accuracy of clinical coding input by physicians in primary care, as part of a consultation, or secondary care, as part of a hospital admission. The validity of diagnoses underlying our study has therefore been carefully assessed and was considered appropriate in light of the following arguments.

Independent validation studies. Three studies are of major importance: (i) a systematic review, published in 2010, reports 212 validation studies over a broad range of conditions with an average positive predictive value of 89%⁵; (ii) a study specifically investigating heart failure diagnoses, which despite it being conducted before the introduction of national care monitoring programs reports a positive predictive value of 82%⁶; and (iii) a more recent study investigating the validity of chronic obstructive pulmonary disease (COPD), another major chronic condition managed in primary care, which reports an accuracy of 87% compared with specialist assessment.⁷

National care monitoring programs. Two national clinical audit programs (in particular the ‘quality and outcomes framework’ (QOF) introduced in 2004 for primary care, and the ‘national heart failure audit’ (NHFA) introduced in 2007 for secondary care) ensure a stable quality of clinical coding practices and provide a solid support for the validity of recorded diagnoses. Indeed, these report that approximately 90% of recorded heart failure diagnoses in England are referred for echocardiography, specialist assessment, or B-type natriuretic peptide (BNP) measurement.^{8,9}

Clinical guidelines. Guidelines for the diagnosis and management of heart failure from the National Institute for Clinical Excellence (NICE)^{10,11} provide additional consistency over the study period. Indeed, guidelines are largely consistent in regard to heart failure diagnostic criteria and recommended investigations. One important change is the availability of natriuretic peptides testing and the variability in assay accuracy; these are however mainly used to exclude suspected cases, as opposed to confirming diagnoses, and therefore unlikely to impact disease incidence rates.^{10,11}

Sensitivity analyses. Finally, to confirm the validity of heart failure cases included in our cohort, we performed the following sensitivity analyses. (a) case identification restricted to diagnostic codes included in national care monitoring programs. While for our main analysis we intentionally expanded the diagnostic codes from the national audit programs list with additional codes indicating a heart failure diagnosis, so as to ensure completeness; sensitivity analyses, restricting diagnostic codes to those used in the national audit programs, found that 97% of patients in our cohort had a record heart failure used in the national clinical audit programs, and led to no significant changes in the present results. (b) case identification restricted to diagnoses recorded in secondary care, or referred for specialist assessment or echocardiography. We further found that 92% of patients included in our cohort had a heart failure diagnosis recorded in secondary care, or either a referral to specialist cardiology service or echocardiography. While that proportion moderately increased over time, we found no significant change by sex or socio-economic status.

eAppendix 4: Accuracy of hospital episodes data

Accuracy of diagnostic coding in routinely collected hospital records in the United Kingdom has been widely studied and findings show that data are sufficiently robust to be used in healthcare research and decision-making. Specifically, a recent systematic review identified 32 studies were that compared routinely collected data with case or operation notes. Although accuracy presented significant variation between studies, their findings show that since the 2002 introduction of the ‘Payment by Results’ program, accuracy has improved, and for primary discharge diagnoses accuracy was 96.0%.¹²

eAppendix 5: Validity of causes of death records

The present research is reliant on the accuracy of death certificates. The validity of death records underlying our study has therefore been carefully assessed. In England and Wales, information collected at death registration is normally supplied by the informant (usually a close relative of the deceased), undergoes automatic validation checks and is verified by the registrar. The cause of death is usually obtained from the ‘Medical Certificate of Cause of Death’, completed by a medical practitioner when the death is certified. The final underlying cause of death takes account of additional information received from medical practitioners or coroners after the death has been registered; around 40% of deaths are referred to the coroner.¹³ The Office for National Statistics (ONS) collects information on all deaths that occur in England and Wales as well as deaths of all ordinary residents.¹³ The dataset used in this study was restricted to patients whose record was linked to death information from ONS death certificates. Mortality data from the Office for National Statistics is used by academics, demographers and health researchers, as well as major national and international health organizations (including Public Health England, Eurostat, and the United Nations) for disease surveillance and epidemiological research. A recent study performed by the ONS has examined causes of death recorded on death certificates in five pilot areas in the UK. The study found on scrutiny of an independent medical examiner, the broad underlying cause of death (as defined by International Classification of Diseases chapter (ICD)) remained unchanged in 88 per cent of cases.¹⁴ In the present study, the 22 ICD chapters were grouped into higher-level disease categories (respectively 9 and 11 disease categories for death and hospitalizations), so that consistency is likely to be even higher than in the aforementioned ONS study. Moreover, no national coding reform has been introduced over the study period and there is no evidence to suggest recording practices to have changed considerably over time or by age, sex, and socioeconomic sub-groups.¹³ In light of this information, we conclude that UK death certificates data may present some level of inaccuracy that must be taken into account in the design and interpretation of studies relying on death registration data; yet that the information is appropriate for the study long-term temporal trends of cause-specific mortality in large populations.

eAppendix 6: Literature review

We searched Pubmed for reports published from 1 January 2012 to 15 February 2019 that included “heart failure” and “mortality” in their title, reviewed references from clinical practice guidelines and consulted with experts for relevant studies. We found numerous studies that investigated mortality following a hospital admission for heart failure, though few studies reported survival rates after incident diagnosis. In an attempt to compare various reports, we selected studies that reported 1-year mortality rates following a new diagnosis of heart failure and (i) referred to European or North American cohorts, (ii) included at least 1,000 patients, (iii) were not restricted to clinical trials, special care management programs, certain age-groups or associated conditions, and (iv) reported trends over time. A few relevant studies were identified (**eTable 1**). Overall these reported improvements in mortality up to around 2005 but stable rates thereafter, despite increasing uptake of new treatments, in particular beta-blockers. Most studies confined investigations to all-cause mortality, with only one study distinguishing between cardiovascular and non-cardiovascular mortality. No study investigated underlying patterns and cause-specific mortality.

eTable 1: Selected studies reporting heart failure mortality rates following incident heart failure.

| Study | Country | Data collection period | Size | Design | Case identification | 1-year mortality rates | | | Comments |
|--|---------|--|---------|----------------------|---|----------------------------------|--|--|--|
| | | | | | | All (trend) | Stratified (trend) | | |
| Taylor 2019 ¹⁵ | UK | 2000 2017 | 55,959 | Retrospective cohort | General practice consultation | 25.8% 19.2% (↓) | | | The study reports modest improvements in survival (6.6% over 17 years). |
| Taylor 2017 ¹⁶ | UK | 1998-2012 | 54,313 | Retrospective cohort | General practice consultation | 18.7% (↔) | | | The study presents crude mortality rates. |
| Gerber 2015 (Olmsted County) ¹⁷ | USA | 2000-2010 | 2,762 | Prospective cohort | Outpatient and hospital discharge records | 20.2% (↔) | CVD 9% (↔) | Non-CVD 11% (↔) | The study reports temporal trends with no decline in mortality rates over time. |
| Yeung 2012 ¹⁸ | Canada | 1997 2007 | 419,551 | Retrospective cohort | Outpatient and hospital discharge records | 27% 25% (↓) | Inpatients 36% 34% (↔) | Outpatients 18% 16% (↓) | Mortality rates presented are age-sex-standardized to the 1991 Ontario population aged > 20 years, and risk-adjusted to patients' comorbidity profiles. |
| Gomez-Soto 2011 ¹⁹ | Spain | 2000 2007 | 4,793 | Prospective cohort | Diagnosis by GP or hospital admission | 31%* 29%* (↓) | Men 35% 34% (↓) | Women 27% 24% (↓) | Risk-adjusted mortality rates accounting for age at incidence, comorbidities, type of heart failure, and source of incident diagnosis (inpatient vs. outpatient). |
| Roger 2004 (Olmsted County) ²⁰ | USA | 1979-1984 1985-1990 1991-1995 1996-2000 | 4,537 | Prospective cohort | Outpatient and hospital discharge records | 25%* 23%* 23%* 19%* (↓) | Men 30% 26% 25% 21% (↓) | Women 20% 19% 20% 17% (↓) | Mortality estimates after onset of heart failure among men and women aged 75 years. Trends compare the last to the first reporting period. |
| Levy 2002 (Framingham) ²¹ | USA | 1950-1969 1970-1979 1980-1989 1990-1999 | 1,075 | Prospective cohort | Population based screening | 29%* 35%* 30%* 26%* (↓) | Men 30% 41% 33% 28% (↓) | Women 28% 28% 27% 24% (↓) | Mortality rates presented refer to men and women aged 65 to 74 years, and are adjusted for age. Trends are adjusted for age, type of heart failure and comorbidities. Trends compare the last to the first reporting period. |

Abbreviations: Heart Failure (HF), General Practice (GP), United Kingdom (UK), United States of America (USA), Cardiovascular (CVD). Trends: ↔ indicates stable trend, ↓ indicates declining trend, and ○ indicates trends are not reported. * Overall rates are not reported; To allow overall comparison, we present estimates as the average of men and women rates. For study selection criteria, please refer to **text S3**.

eTable 2: Diagnostic codes that refer to a new diagnosis of heart failure**A. ICD-10 codes used in hospital records**

| Code | Description |
|-------------|---|
| I50.0 | Congestive heart failure |
| I50.1 | Left ventricular failure |
| I50.9 | Heart failure, unspecified |
| I42.0 | Dilated cardiomyopathy (Congestive cardiomyopathy) |
| I42.9 | Cardiomyopathy, unspecified |
| I11.0 | Hypertensive heart disease with (congestive) heart failure |
| I25.5 | Ischaemic cardiomyopathy |
| I13.2 | Hypertensive heart and renal disease with both (congestive) heart failure and renal failure |
| I13.0 | Hypertensive heart and renal disease with (congestive) heart failure |

B. Read codes used in general practice records

| Medcode | Read Code | Description |
|----------------|------------------|--|
| 884 | G581.00 | Left ventricular failure |
| 2062 | G58..00 | Heart failure |
| 2906 | G580.11 | Congestive cardiac failure |
| 398 | G580.00 | Congestive heart failure |
| 8966 | G5yy900 | Left Ventricular Systolic Dysfunction |
| 3204 | G55..00 | Cardiomyopathy |
| 11284 | 585f.00 | Echocardiogram shows left ventricular systolic dysfunction |
| 1223 | G58..11 | Cardiac failure |
| 5942 | G581.13 | Impaired left ventricular function |
| 7251 | 33BA.00 | Impaired Left Ventricular Function |
| 9913 | 1O1..00 | Heart failure confirmed |
| 12550 | G5yyA00 | Left Ventricular Diastolic dysfunction |
| 8010 | G551.00 | Hypertrophic obstructive cardiomyopathy |
| 5695 | G41z.11 | Chronic cor pulmonale |
| 4024 | G58z.00 | Heart failure NOS |
| 11351 | 585g.00 | Echo shows LVDD |
| 7535 | G554400 | Primary dilated cardiomyopathy |
| 13189 | 662g.00 | New York Heart Association classification - class II |
| 5255 | G581000 | Acute left ventricular failure |
| 10079 | G580.12 | Right heart failure |
| 3499 | G554300 | Hypertrophic non-obstructive cardiomyopathy |
| 16383 | 1O1..00 | Heart failure confirmed |
| 9524 | G580.14 | Biventricular failure |
| 7320 | G343.00 | Ischaemic cardiomyopathy |
| 17278 | G58z.12 | Cardiac failure NOS |
| 19066 | 662h.00 | New York Heart Association classification - class III |
| 27964 | G582.00 | Acute heart failure |
| 22993 | G55z.00 | Cardiomyopathy NOS |
| 107397 | G5yyD00 | Left ventricular cardiac dysfunction |
| 18853 | 662f.00 | NYHA class f - i |
| 101138 | G583.00 | Heart failure with normal ejection fraction |

| Medcode | Read Code | Description |
|---------|-----------|--|
| 32671 | G580100 | Chronic congestive heart failure |
| 4915 | G555.00 | Alcoholic cardiomyopathy |
| 10154 | G580.13 | Right ventricular failure |
| 9402 | G55y.11 | Secondary dilated cardiomyopathy |
| 27884 | G580200 | Decompensated cardiac failure |
| 32898 | 8H2S.00 | Admit heart failure emergency |
| 21852 | G554200 | Familial cardiomyopathy |
| 106897 | G583.12 | Heart failure with preserved ejection fraction |
| 104275 | G584.00 | Right ventricular failure |
| 5141 | G554000 | Congestive cardiomyopathy |
| 11424 | G580300 | Compensated cardiac failure |
| 97780 | G559.00 | Arrhythmogenic right ventricular cardiomyopathy |
| 101137 | G583.11 | HFNEF - heart failure with normal ejection fraction |
| 106008 | 8CMW800 | Heart failure clinical pathway |
| 94870 | G580400 | Congestive heart failure due to valvular disease |
| 27683 | G558100 | Cardiomyopathy in myotonic dystrophy |
| 70648 | Gyu5M00 | Other hypertrophic cardiomyopathy |
| 22262 | G1yz100 | Rheumatic left ventricular failure |
| 51214 | 662i.00 | New York Heart Association classification - class IV |
| 106198 | 661M500 | Heart failure self-management plan agreed |
| 103732 | 8CMK.00 | Has heart failure management plan |
| 62718 | G21z100 | Hypertensive heart disease NOS with CCF |
| 52127 | G211100 | Benign hypertensive heart disease with CCF |
| 21837 | G232.00 | Hypertensive heart & renal dis with (congestive) heart failure |
| 105542 | 8CeC.00 | Preferred place of care for next exacerbation HF |

Abbreviations: 'HF-REF' = heart failure with reduced ejection fraction (highlighted in blue); 'HF-UNS' = heart failure with unspecified ejection fraction. 'NHFA' identifies those codes used by the National Heart Failure Audit to identify patients with a heart failure diagnosis from hospital discharge records. 'QOF HF' identifies those codes used by the 2014 Quality and Outcomes Framework to identify patients with a heart failure diagnosis from general practice records. 'QOF LVSD' refers to codes used by the 2014 Quality and Outcomes Framework to identify patients with a left ventricular systolic dysfunction diagnosis from general practice records.

eTable 3: Diagnostic codes that refer to pre-existing heart failure

| Code Type | Medcode | Readcode | Description |
|------------------|----------------|-----------------|---|
| READ | 95021 | 9N4s.00 | Did not attend practice nurse heart failure clinic |
| READ | 24503 | 8B29.00 | Cardiac failure therapy |
| READ | 95835 | 679X.00 | Heart failure education |
| READ | 26115 | 8HHb.00 | Referral to heart failure nurse |
| READ | 5155 | 23E1.00 | O/E - pulmonary oedema |
| READ | 90935 | 9hH..00 | Exception reporting: heart failure quality indicators |
| READ | 30749 | 9hH0.00 | Excepted heart failure quality indicators: Patient unsuitable |
| READ | 34213 | 9h1..00 | Exception reporting: LVD quality indicators |
| READ | 11613 | 9h11.00 | Excepted from LVD quality indicators: Patient unsuitable |
| READ | 28649 | 9h12.00 | Excepted from LVD quality indicators: Informed dissent |
| READ | 15058 | 14A6.00 | H/O: heart failure |
| READ | 46912 | 14AM.00 | H/O: Heart failure in last year |
| READ | 83502 | 662p.00 | Heart failure 6-month review |
| READ | 12366 | 662T.00 | Congestive heart failure monitoring |
| READ | 30779 | 662W.00 | Heart failure annual review |
| READ | 32945 | 8CL3.00 | Heart failure care plan discussed with patient |
| READ | 17851 | 8HBE.00 | Heart failure follow-up |
| READ | 70619 | 8HHz.00 | Referral to heart failure exercise programme |
| READ | 71235 | 8Hk0.00 | Referred to heart failure education group |
| READ | 64062 | 9hH1.00 | Excepted heart failure quality indicators: Informed dissent |
| READ | 32911 | 9Or..00 | Heart failure monitoring administration |
| READ | 19380 | 9Or0.00 | Heart failure review completed |
| READ | 90193 | 9Or1.00 | Heart failure monitoring telephone invite |
| READ | 90192 | 9Or2.00 | Heart failure monitoring verbal invite |
| READ | 72965 | 9Or3.00 | Heart failure monitoring first letter |
| READ | 72386 | 9Or4.00 | Heart failure monitoring second letter |
| READ | 89650 | 9Or5.00 | Heart failure monitoring third letter |
| READ | 18793 | 9On..00 | Left ventricular dysfunction monitoring administration |
| READ | 60710 | 9On0.00 | Left ventricular dysfunction monitoring first letter |
| READ | 60721 | 9On1.00 | Left ventricular dysfunction monitoring second letter |
| READ | 72341 | 9On2.00 | Left ventricular dysfunction monitoring third letter |
| READ | 92305 | 9On3.00 | Left ventricular dysfunction monitoring verbal invite |
| READ | 96484 | 9On4.00 | Left ventricular dysfunction monitoring telephone invite |
| READ | 100784 | 2126400 | Heart Failure Resolved |
| READ | 102585 | 8HgD.00 | Discharge from heart failure nurse service |
| READ | 106680 | 8HTL000 | Referral to rapid access heart failure clinic |
| READ | 106836 | 8IB8.00 | Referral to heart failure exercise programme not indicated |
| READ | 106894 | 8IE1.00 | Referral to heart failure exercise programme declined |
| READ | 107981 | 8IE0.00 | Referral to heart failure education group declined |
| READ | 42999 | 12CR.00 | FH: Hypertrophic obstructive cardiomyopathy |

eTable 4: Definition of disease categories for causes of deaths and hospitalizations

| Causes of death | Causes of hospitalization |
|--|--|
| <p>Cardiovascular disorders: ICD chapter 'Diseases of the circulatory system' (code range: I00–I99), excluding codes relating to infections.</p> | <p>Heart failure: ICD codes: I50 'Heart failure' (incl. I50.0, I50.1, I50.9), I42.0 'Dilated cardiomyopathy', I42.9 'Cardiomyopathy, unspecified', I11.0 'Hypertensive heart disease with (congestive) heart failure', I25.5 'Ischemic cardiomyopathy', I13.0 'Hypertensive heart and renal disease with (congestive) heart failure', I13.2 'Hypertensive heart and renal disease with both (congestive) heart failure and renal failure'.</p> <p>Other cardiovascular disorders: ICD chapter 'Diseases of the circulatory system' (code range: I00–I99), excluding codes relating to heart failure or infections.</p> |
| <p>Neoplasms: ICD chapter 'Neoplasms' (C00–D48).</p> | |
| <p>Infections: infectious and parasitic diseases, respiratory infections, urinary tract infections, and cellulitis, as defined by individual codes listed in eTable 6.</p> | |
| <p>Chronic respiratory diseases: individual codes listed in eTable 7.</p> | |
| <p>Digestive diseases: ICD chapter: 'Diseases of the digestive system' (K00–K93), excepting selected codes categorized as infections.</p> | |
| <p>Mental and neurological disorders: ICD chapter 'Mental and behavioral disorders' (F00–F99) and ICD chapter 'Diseases of the nervous system' (G00–G99)</p> | |
| <p>---</p> | <p>Musculoskeletal disorders: ICD chapter 'Diseases of the musculoskeletal system and connective tissue' (M00–M99).</p> |
| <p>Injuries: ICD chapters 'Injury, poisoning and certain other consequences of external causes' (S00–T98) and 'External causes of morbidity and mortality' (V01–Y98)</p> | |
| <p>Kidney diseases ICD sub-chapters 'Renal failure' (N17–N19), 'Glomerular diseases' (N00–N08), 'Renal tubulo-interstitial diseases' (N10–N16), 'Other disorders of kidney and ureter' (N25–N29).</p> | |
| <p>Other: any code not falling into any of the above categories.</p> | <p>Other: ICD chapter 'Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified' (R00–R99) as well as any code not falling into any of the above categories.</p> |
| <p>In sub-group analyses, categories were grouped into cardiovascular (heart failure and other cardiovascular) causes and non-cardiovascular causes (all other categories).</p> | |

eTable 5: Number of deaths due to cardiovascular diseases, neoplasms, infections, and chronic respiratory diseases, by disease sub-group

| | All years (n = 27,398) | 2002-2004 (n=6,884) | 2011-2013 (n=6,616) |
|---|----------------------------------|-------------------------------|-------------------------------|
| Cardiovascular diseases | | | |
| Chronic ischemic heart disease | 4,881 (34%) | 1,501 (38%) | 848 (29%) |
| Acute myocardial infarction | 3,010 (21%) | 868 (22%) | 583 (20%) |
| Heart failure | 1,794 (13%) | 509 (13%) | 295 (10%) |
| Cerebrovascular diseases | 1,619 (11%) | 396 (10%) | 386 (13%) |
| Other forms of heart disease | 3,027 (21%) | 687 (17%) | 862 (29%) |
| Neoplasms | | | |
| Malignant neoplasms of digestive organs | 819 (22%) | 219 (25%) | 211 (21%) |
| Malignant neoplasms of respiratory and intrathoracic organs | 708 (19%) | 184 (21%) | 190 (19%) |
| Malignant neoplasms of lymphoid, hematopoietic and related tissue | 533 (14%) | 102 (12%) | 155 (16%) |
| Malignant neoplasms of male genital organs | 374 (10%) | 90 (10%) | 107 (11%) |
| Malignant neoplasms of urinary tract | 237 (6%) | 53 (6%) | 66 (7%) |
| Malignant neoplasm of breast | 227 (6%) | 50 (6%) | 62 (6%) |
| Other | 830 (22%) | 183 (21%) | 204 (21%) |
| Infections | | | |
| Influenza and pneumonia | 1,915 (64%) | 411 (72%) | 566 (69%) |
| Other forms of respiratory infections | 137 (5%) | 13 (2%) | 28 (3%) |
| Urinary tract infections | 351 (12%) | 50 (9%) | 74 (9%) |
| Sepsis | 192 (6%) | 23 (4%) | 59 (7%) |
| Intestinal infectious diseases | 146 (5%) | 20 (4%) | 30 (4%) |
| Cellulitis | 88 (3%) | 11 (2%) | 34 (4%) |
| Infections affecting the heart | 61 (2%) | 15 (3%) | 14 (2%) |
| Tuberculosis | 17 (1%) | 6 (1%) | 3 (0%) |
| Other infectious or parasitic diseases | 62 (2%) | 20 (4%) | 18 (2%) |
| Chronic respiratory diseases | | | |
| Chronic obstructive pulmonary disease | 1,907 (67%) | 477 (73%) | 460 (64%) |
| Interstitial lung disease and pulmonary sarcoidosis | 493 (17%) | 74 (11%) | 170 (24%) |
| Asthma | 62 (2%) | 13 (2%) | 15 (2%) |
| Pneumoconiosis | 24 (1%) | 4 (1%) | 12 (2%) |
| Other chronic respiratory diseases | 341 (12%) | 84 (13%) | 58 (8%) |
| Mental health and neurological disorders | | | |
| Dementia | 386 (55%) | 46 (39%) | 199 (70%) |
| Alzheimer | 85 (12%) | 18 (15%) | 23 (8%) |
| Other diseases of the nervous system | 207 (30%) | 47 (40%) | 58 (20%) |
| Other mental and behavioral disorders | 22 (3%) | 6 (5%) | 4 (1%) |

Injuries

| | | | |
|--|-----------|----------|----------|
| Accidental exposure to unspecified factor | 202 (43%) | 37 (49%) | 48 (38%) |
| Falls | 152 (33%) | 18 (24%) | 44 (35%) |
| Complications of medical and surgical care | 39 (8%) | 14 (19%) | 17 (14%) |
| Other external causes of morbidity and mortality | 74 (16%) | 6 (8%) | 16 (13%) |

N refers to the number of deaths at 1 year attributed to individual causes. Percentages refer to the total number of deaths within each disease category. Clinical codes used to identify each disease group are available upon request.

eTable 6: Clinical codes used to categorize causes of death or hospitalization as infections

A. Infectious diseases

| ICD Code | Description |
|----------|---|
| A00–B99 | Certain infectious and parasitic diseases |

B. Other respiratory infections, not categorized as infectious and parasitic diseases

| ICD Code | Description |
|----------|---|
| H65 | Nonsuppurative otitis media |
| H65.0 | Acute serous otitis media |
| H65.1 | Other acute nonsuppurative otitis media |
| H65.2 | Chronic serous otitis media |
| H65.3 | Chronic mucoid otitis media |
| H65.4 | Other chronic nonsuppurative otitis media |
| H66 | Suppurative and unspecified otitis media |
| H66.0 | Acute suppurative otitis media |
| H66.1 | Chronic tubotympanic suppurative otitis media |
| H66.2 | Chronic atticofacial suppurative otitis media |
| H72 | Perforation of tympanic membrane |
| H72.0 | Central perforation of tympanic membrane |
| H72.1 | Attic perforation of tympanic membrane |
| H72.2 | Other marginal perforations of tympanic membrane |
| H72.8 | Other perforations of tympanic membrane |
| H72.9 | Unspecified perforation of tympanic membrane |
| H73 | Other disorders of tympanic membrane |
| H73.0 | Acute myringitis |
| H73.1 | Chronic myringitis |
| H73.2 | Unspecified myringitis |
| H73.8 | Other specified disorders of tympanic membrane |
| H73.9 | Unspecified disorder of tympanic membrane |
| H80 | Otosclerosis |
| H80.0 | Otosclerosis involving oval window, nonobliterative |
| H80.1 | Otosclerosis involving oval window, obliterative |
| H80.2 | Cochlear otosclerosis |
| H80.8 | Other otosclerosis |
| H80.9 | Unspecified otosclerosis |
| H83 | Other diseases of inner ear |
| H83.0 | Labyrinthitis |
| H83.1 | Labyrinthine fistula |
| H83.2 | Labyrinthine dysfunction |
| H83.3 | Noise effects on inner ear |
| H83.8 | Other specified diseases of inner ear |
| H83.9 | Unspecified disease of inner ear |
| J01 | Acute sinusitis |
| J01.0 | Acute maxillary sinusitis |
| J01.1 | Acute frontal sinusitis |
| J01.2 | Acute ethmoidal sinusitis |
| J01.3 | Acute sphenoidal sinusitis |
| J01.4 | Acute pansinusitis |
| J01.8 | Other acute sinusitis |
| J01.9 | Acute sinusitis, unspecified |
| J02.0 | Streptococcal pharyngitis |
| J02.8 | Acute pharyngitis due to other specified organisms |
| J02.9 | Acute pharyngitis, unspecified |
| J03.0 | Streptococcal tonsillitis |
| J03.8 | Acute tonsillitis due to other specified organisms |
| J03.9 | Acute tonsillitis, unspecified |
| J04 | Acute laryngitis and tracheitis |
| J04.0 | Acute laryngitis |
| J04.1 | Acute tracheitis |
| J04.2 | Acute laryngotracheitis |
| J04.3 | Supraglottitis, unspecified |
| J05 | Acute obstructive laryngitis [croup] and epiglottitis |

| ICD Code | Description |
|----------|--|
| J05.0 | Acute obstructive laryngitis [croup] |
| J05.1 | Acute epiglottitis |
| J06.0 | Acute laryngopharyngitis |
| J06.8 | Other acute upper respiratory infections of multiple sites |
| J06.9 | Acute upper respiratory infection, unspecified |
| J09 | Influenza due to identified zoonotic or pandemic influenza virus |
| J10 | Influenza due to other identified influenza virus |
| J10.0 | Influenza due to oth identified influenza virus w pneumonia |
| J10.1 | Flu due to oth ident influenza virus w oth resp manifest |
| J10.2 | Influenza due to oth ident influenza virus w GI manifest |
| J10.8 | Influenza due to oth ident influenza virus w oth manifest |
| J11 | Influenza due to unidentified influenza virus |
| J11.0 | Influenza due to unidentified influenza virus with pneumonia |
| J11.1 | Flu due to unidentified influenza virus w oth resp manifest |
| J11.2 | Influenza due to unidentified influenza virus w GI manifest |
| J11.8 | Influenza due to unidentified influenza virus w oth manifest |
| J12 | Viral pneumonia, not elsewhere classified |
| J12.0 | Adenoviral pneumonia |
| J12.1 | Respiratory syncytial virus pneumonia |
| J12.2 | Parainfluenza virus pneumonia |
| J12.3 | Human metapneumovirus pneumonia |
| J12.8 | Other viral pneumonia |
| J12.9 | Viral pneumonia, unspecified |
| J13 | Pneumonia due to Streptococcus pneumoniae |
| J14 | Pneumonia due to Haemophilus influenzae |
| J15 | Bacterial pneumonia, not elsewhere classified |
| J15.0 | Pneumonia due to Klebsiella pneumoniae |
| J15.1 | Pneumonia due to Pseudomonas |
| J15.2 | Pneumonia due to staphylococcus |
| J15.3 | Pneumonia due to streptococcus, group B |
| J15.4 | Pneumonia due to other streptococci |
| J15.5 | Pneumonia due to Escherichia coli |
| J15.6 | Pneumonia due to other aerobic Gram-negative bacteria |
| J15.7 | Pneumonia due to Mycoplasma pneumoniae |
| J15.8 | Pneumonia due to other specified bacteria |
| J15.9 | Unspecified bacterial pneumonia |
| J16.0 | Chlamydial pneumonia |
| J16.8 | Pneumonia due to other specified infectious organisms |
| J17 | Pneumonia in diseases classified elsewhere |
| J17.0 | Pneumonia in bacterial diseases classified elsewhere |
| J17.1 | Pneumonia in viral diseases classified elsewhere |
| J17.2 | Pneumonia in mycoses |
| J17.3 | Pneumonia in parasitic diseases |
| J17.8 | Pneumonia in other diseases classified elsewhere |
| J18 | Pneumonia, unspecified organism |
| J18.0 | Bronchopneumonia, unspecified organism |
| J18.1 | Lobar pneumonia, unspecified organism |
| J18.2 | Hypostatic pneumonia, unspecified organism |
| J18.8 | Other pneumonia, unspecified organism |
| J18.9 | Pneumonia, unspecified organism |
| J20 | Acute bronchitis |
| J20.0 | Acute bronchitis due to Mycoplasma pneumoniae |
| J20.1 | Acute bronchitis due to Hemophilus influenzae |
| J20.2 | Acute bronchitis due to streptococcus |
| J20.3 | Acute bronchitis due to coxsackievirus |
| J20.4 | Acute bronchitis due to parainfluenza virus |
| J20.5 | Acute bronchitis due to respiratory syncytial virus |
| J20.6 | Acute bronchitis due to rhinovirus |
| J20.7 | Acute bronchitis due to echovirus |
| J20.8 | Acute bronchitis due to other specified organisms |
| J20.9 | Acute bronchitis, unspecified |
| J21 | Acute bronchiolitis |
| J21.0 | Acute bronchiolitis due to respiratory syncytial virus |

| ICD Code | Description |
|----------|---|
| J21.1 | Acute bronchiolitis due to human metapneumovirus |
| J21.8 | Acute bronchiolitis due to other specified organisms |
| J21.9 | Acute bronchiolitis, unspecified |
| J22 | Unspecified acute lower respiratory infection |
| J32.9 | Chronic sinusitis, unspecified |
| J40 | Bronchitis, not specified as acute or chronic |
| J85.1 | Abscess of lung with pneumonia |
| J86.9 | Pyothorax without fistula |
| K67.3 | Tuberculous peritonitis |
| K93.0 | Tuberculous disorders of intestines, peritoneum and mesenteric glands |
| N74.1 | Female tuberculous pelvic inflammatory disease |

C. Urinary tract infections

| ICD Code | Description |
|----------|---|
| N11 | Chronic tubulointerstitial nephritis |
| N11.0 | Nonobstructive reflux-associated chronic pyelonephritis |
| N11.1 | Chronic obstructive pyelonephritis |
| N11.8 | Other chronic tubulointerstitial nephritis |
| N11.9 | Chronic tubulointerstitial nephritis, unspecified |
| N15 | Other renal tubulointerstitial diseases |
| N15.0 | Balkan nephropathy |
| N15.1 | Renal and perinephric abscess |
| N30 | Cystitis |
| N30.0 | Acute cystitis |
| N30.1 | Interstitial cystitis (chronic) |
| N30.2 | Other chronic cystitis |
| N30.3 | Trigonitis |
| N30.4 | Irradiation cystitis |
| N30.8 | Other cystitis |
| N30.9 | Cystitis, unspecified |
| N34 | Urethritis and urethral syndrome |
| N34.0 | Urethral abscess |
| N34.1 | Nonspecific urethritis |
| N34.2 | Other urethritis |
| N34.3 | Urethral syndrome, unspecified |
| N39.0 | Urinary tract infection, site not specified |

D. Other infectious diseases

| ICD Code | Description |
|----------|--|
| G00 | Bacterial meningitis, not elsewhere classified |
| G00.0 | Hemophilus meningitis |
| G00.1 | Pneumococcal meningitis |
| G00.2 | Streptococcal meningitis |
| G00.3 | Staphylococcal meningitis |
| G00.8 | Other bacterial meningitis |
| G00.9 | Bacterial meningitis, unspecified |
| G03 | Meningitis due to other and unspecified causes |
| G03.0 | Nonpyogenic meningitis |
| G03.1 | Chronic meningitis |
| G03.2 | Benign recurrent meningitis [Mollaret] |
| G03.8 | Meningitis due to other specified causes |
| G03.9 | Meningitis, unspecified |
| G04 | Encephalitis, myelitis and encephalomyelitis |
| G04.0 | Acute disseminated encephalitis and encephalomyelitis (ADEM) |
| G04.1 | Tropical spastic paraplegia |
| G04.2 | Bacterial meningoencephalitis and meningomyelitis, NEC |
| G04.3 | Acute necrotizing hemorrhagic encephalopathy |
| G04.8 | Other encephalitis, myelitis and encephalomyelitis |
| G04.9 | Encephalitis, myelitis and encephalomyelitis, unspecified |
| H70.1 | Chronic mastoiditis |

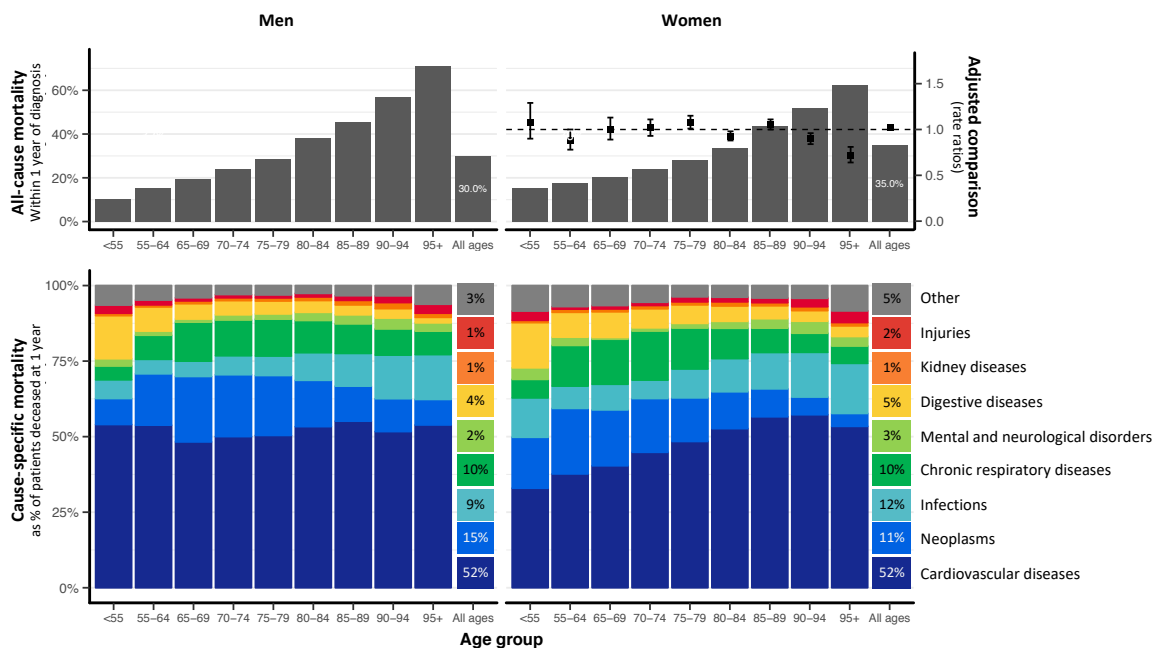
| ICD Code | Description |
|-----------------|--|
| I00 | Rheumatic fever without mention of heart involvement |
| I01 | Rheumatic fever with heart involvement |
| I01.0 | Acute rheumatic pericarditis |
| I01.1 | Acute rheumatic endocarditis |
| I01.2 | Acute rheumatic myocarditis |
| I01.8 | Other acute rheumatic heart disease |
| I01.9 | Acute rheumatic heart disease, unspecified |
| I02 | Rheumatic chorea |
| I02.0 | Rheumatic chorea with heart involvement |
| I02.9 | Rheumatic chorea without heart involvement |
| I30 | Acute pericarditis |
| I30.0 | Acute nonspecific idiopathic pericarditis |
| I30.1 | Infective pericarditis |
| I30.8 | Other forms of acute pericarditis |
| I30.9 | Acute pericarditis, unspecified |
| I33 | Acute and subacute endocarditis |
| I33.0 | Acute and subacute infective endocarditis |
| I33.9 | Acute endocarditis, unspecified |
| I40 | Acute myocarditis |
| I40.0 | Infective myocarditis |
| I40.1 | Isolated myocarditis |
| I40.8 | Other acute myocarditis |
| I40.9 | Acute myocarditis, unspecified |
| L03 | Cellulitis |

eTable 7: Clinical codes used to categorize causes of death or hospitalization as chronic respiratory diseases

| ICD Code | Description |
|----------|--|
| D86 | Sarcoidosis |
| D86.0 | Sarcoidosis of lung |
| D86.1 | Sarcoidosis of lymph nodes |
| D86.2 | Sarcoidosis of lung with sarcoidosis of lymph nodes |
| D86.8 | Sarcoidosis of other sites |
| D86.9 | Sarcoidosis, unspecified |
| J38.0 | Paralysis of vocal cords and larynx |
| J38.6 | Stenosis of larynx |
| J39.0 | Retropharyngeal and parapharyngeal abscess |
| J39.2 | Other diseases of pharynx |
| J39.8 | Other specified diseases of upper respiratory tract |
| J41 | Simple and mucopurulent chronic bronchitis |
| J41.0 | Simple chronic bronchitis |
| J41.1 | Mucopurulent chronic bronchitis |
| J41.8 | Mixed simple and mucopurulent chronic bronchitis |
| J42 | Unspecified chronic bronchitis |
| J43 | Emphysema |
| J43.0 | Unilateral pulmonary emphysema [MacLeod s syndrome] |
| J43.1 | Panlobular emphysema |
| J43.2 | Centrilobular emphysema |
| J43.8 | Other emphysema |
| J43.9 | Emphysema, unspecified |
| J44 | Other chronic obstructive pulmonary disease |
| J44.0 | Chronic obstructive pulmonary disease with acute lower respiratory infection |
| J44.1 | Chronic obstructive pulmonary disease with (acute) exacerbation |
| J44.8 | Other specified chronic obstructive pulmonary disease |
| J44.9 | Chronic obstructive pulmonary disease, unspecified |
| J45 | Asthma |
| J45.0 | Predominantly allergic asthma |
| J45.1 | Nonallergic asthma |
| J45.2 | Mild intermittent asthma |
| J45.3 | Mild persistent asthma |
| J45.4 | Moderate persistent asthma |
| J45.5 | Severe persistent asthma |
| J45.8 | Mixed asthma |
| J45.9 | Other and unspecified asthma |
| J46 | Status asthmaticus |
| J47 | Bronchiectasis |
| J47.0 | Bronchiectasis with acute lower respiratory infection |
| J47.1 | Bronchiectasis with (acute) exacerbation |
| J47.9 | Bronchiectasis, uncomplicated |
| J60 | Coalworker s pneumoconiosis |
| J61 | Pneumoconiosis due to asbestos and other mineral fibers |
| J62.0 | Pneumoconiosis due to talc dust |
| J62.8 | Pneumoconiosis due to other dust containing silica |
| J63 | Pneumoconiosis due to other inorganic dusts |
| J63.0 | Aluminosis (of lung) |
| J63.1 | Bauxite fibrosis (of lung) |
| J63.2 | Berylliosis |
| J63.3 | Graphite fibrosis (of lung) |
| J63.4 | Siderosis |
| J63.5 | Stannosis |
| J63.8 | Pneumoconiosis due to other specified inorganic dusts |
| J64 | Unspecified pneumoconiosis |
| J67.0 | Farmer lung |
| J67.9 | Hypersensitivity pneumonitis due to unspecified organic dust |
| J69.0 | Pneumonitis due to food and vomit |
| J81 | Pulmonary oedema |
| J82 | Pulmonary eosinophilia, not elsewhere classified |
| J84 | Other interstitial pulmonary diseases |

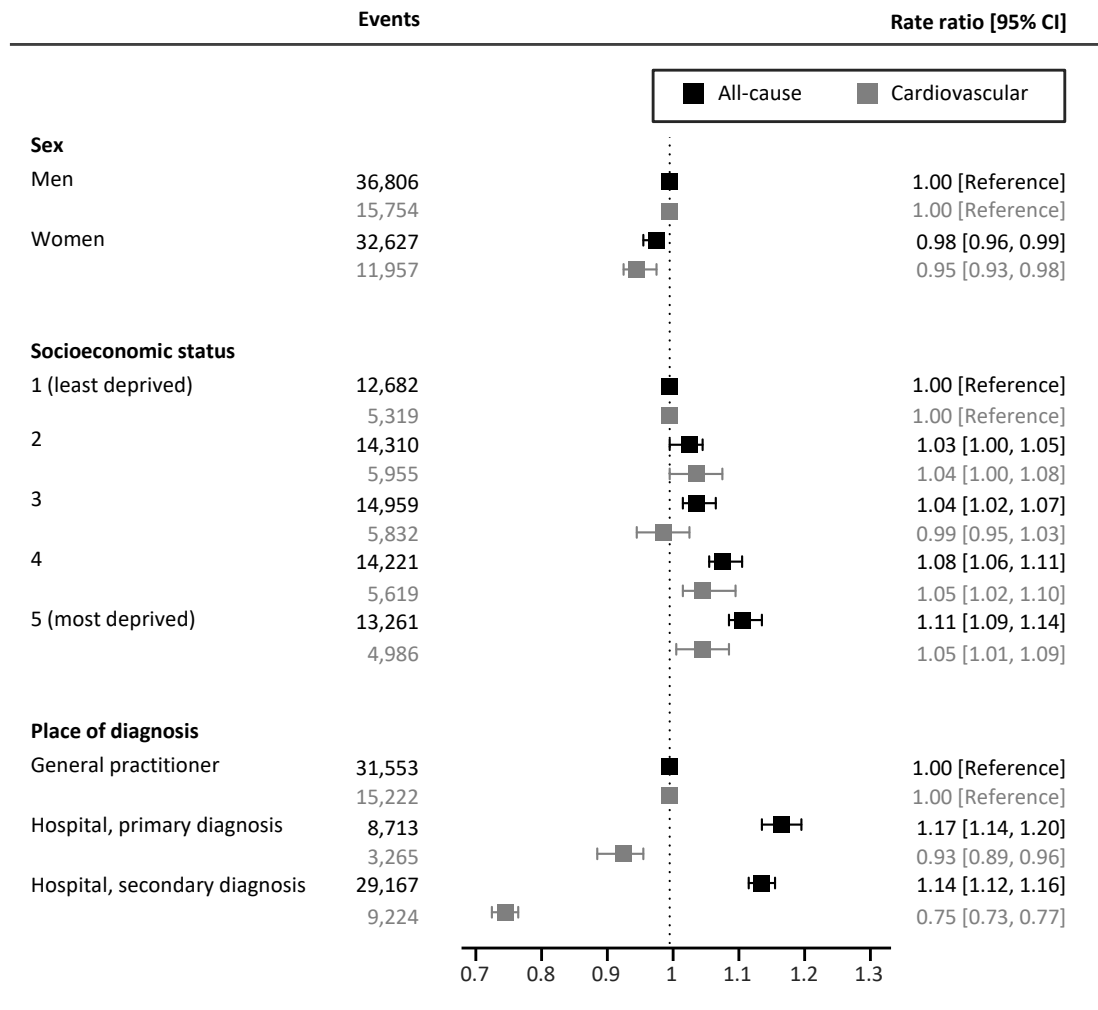
| ICD Code | Description |
|-----------------|---|
| J84.0 | Alveolar and parietoalveolar conditions |
| J84.1 | Other interstitial pulmonary diseases with fibrosis |
| J84.2 | Lymphoid interstitial pneumonia |
| J84.8 | Other specified interstitial pulmonary diseases |
| J84.9 | Interstitial pulmonary disease, unspecified |
| J90 | Pleural effusion, not elsewhere classified |
| J92.0 | Pleural plaque with presence of asbestos |
| J93.1 | Other spontaneous pneumothorax |
| J93.9 | Pneumothorax, unspecified |
| J94.1 | Fibrothorax |
| J94.8 | Other specified pleural conditions |
| J96.1 | Chronic respiratory failure |
| J96.9 | Respiratory failure, unspecified |
| J98.1 | Pulmonary collapse |
| J98.4 | Other disorders of lung |
| J98.8 | Other specified respiratory disorders |
| J98.9 | Respiratory disorder, unspecified |

Figure 1: All-cause and cause-specific mortality rates at 1-year following incident heart failure, by age and sex.



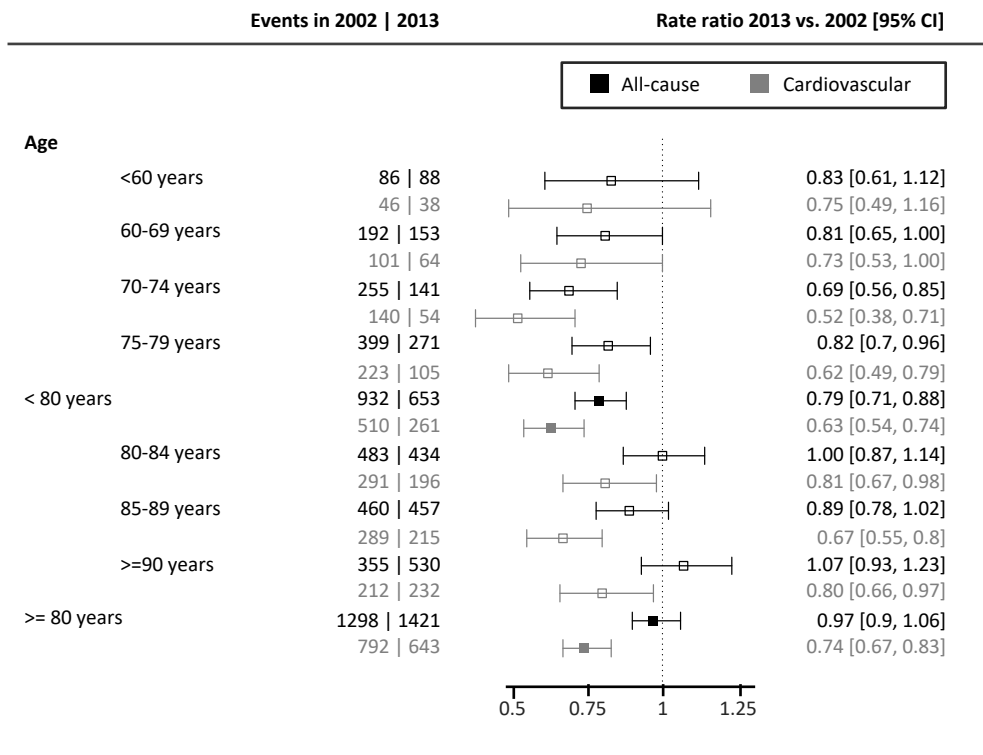
Crude rates of all-cause mortality rates at 1 year following incident heart failure diagnosis, as well as cause-specific mortality presented as a proportion of patients deceased at 1-year. Adjusted comparison present rate ratios for all-cause mortality at 1 year in women versus men from multivariable Poisson regression models adjusting for year of diagnosis, socioeconomic status, region, and 17 baseline comorbidities.

eFigure 2: Differences in hospital admissions within a year of incident heart failure, by sex, socioeconomic status and diagnosis care setting.



Hospital admissions refer to the number of admissions per patient-years at risk within a year of incident heart failure diagnosis. Rate ratios and 95% confidence intervals (CI) from multivariable Poisson regression models accounting for year of diagnosis, age (as a continuous variable), sex, socioeconomic status, region, and 17 baseline comorbidities. Socioeconomic status refers to Index of Multiple Deprivation 2015 quintile, with 1 referring to the most affluent and 5 to the most deprived socioeconomic quintile.

eFigure 3: Temporal trends in one-year mortality rates following incident heart failure, by age group.



Rate ratios and 95% confidence intervals (CI) comparing 2013 and 2002, from multivariable Poisson regression models accounting for year of diagnosis, age (as a continuous variable), sex, socioeconomic status, region, and 17 baseline comorbidities.

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