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Identification of heart failure events in CMS-Medicare claims. The Atherosclerosis Risk in communities (ARIC) Study

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Abstract

Background—We examined the accuracy of CMS Medicare HF diagnostic codes in the identification of acute decompensated and chronic stable HF (ADHF and CSHF).

Methods and Results—Hospitalizations were identified from medical discharge records for ARIC study participants with linked CMS Medicare Provider Analysis and Review (MedPAR) files for the years 2005–2009. The ARIC Study classification of ADHF and CSHF, based on adjudicated review of medical records, was considered the "gold standard".

A total 8,239 ARIC medical records and MedPAR records meeting fee-for-service (FFS) criteria matched on unique participant ID and date of discharge (68.5% match). Agreement between HF diagnostic codes from the two data sources found in the matched records for codes in any position (kappa coefficient (κ) >0.9) was attenuated for primary diagnostic codes (κ<0.8). Sensitivity of HF diagnostic codes found in CMS Medicare claims in the identification of ADHF and CSHF was low, especially for the primary diagnostic codes.

Conclusion—Matching of hospitalizations from CMS Medicare claims with those obtained from abstracted medical records is incomplete, even for hospitalizations meeting FFS criteria. Within matched records, HF diagnostic codes from CMS Medicare show excellent agreement with HF diagnostic codes obtained from medical record abstraction. CMS Medicare data may, however, over-estimate the occurrence of hospitalized acute decompensated or chronic stable HF.

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BACKGROUND

Administrative healthcare data provide an important resource for efforts aimed at the understanding of optimal care for heart failure (HF). However, identification of hospitalized HF events from administrative claims[1] can only be achieved through a review of diagnostic discharge codes and as such it is potentially subject to bias due to discrepancies in coding accuracy. Understanding the validity of claims-based diagnoses of hospitalized HF in relation to existing established HF classification criteria is critical to reliable use of administrative claims in HF research.

In this manuscript we present an assessment of the agreement between hospitalized HF events identified on the basis of diagnostic codes obtained from hospitalization records for participants of the Atherosclerosis Risk in Communities (ARIC) Study, a longitudinal population-based study of cardiovascular disease etiology[2] and from linked Centers for Medicare and Medicaid Services (CMS) claims. We also report on the validity of the diagnostic discharge codes available from CMS Medicare hospitalization records in the identification of HF events as acute decompensated and chronic stable HF[3]. This classification is unique to the ARIC study in comparison with other HF classifications[4–7], including the Framingham HF classification[4], which has been used most frequently in the validation of claims-based HF events.

METHODS

Study population

The ARIC study cohort was established in 1987–1989 as a probability sample of 15,792 men and women, aged 45 to 64 years, from the following four communities in the United States: suburbs of Minneapolis, Minnesota; Forsyth County, North Carolina; Washington County, Maryland; and Jackson, Mississippi. Extensive physical examinations were performed at baseline and at four subsequent clinic visits. Ongoing follow-up of the ARIC cohort is conducted through semi-annual telephone interviews and surveillance of mortality and cardiovascular morbidity.

Data for ARIC cohort participants were linked with the Centers for Medicare and Medicaid Services (CMS) claims data for the years 1991–2012 using a finder file that included participants' social security numbers, gender and date of birth. From the total number of study participants with available social security numbers (n=15,744), 238 died before 1991 and 607 died after 1991 but before reaching the CMS Medicare eligibility age of 65 years, leaving 14,899 eligible ARIC study participants.

The crosswalk file between the ARIC study finder file and the CMS Medicare Beneficiary Summary file yielded 14,702 ARIC cohort IDs (98.7 % match), 13,746 of which included a perfect match on all three finder file variables, 952 of which were additionally matched on just the social security number and gender and 4 of which were additionally matched on just the social security number and birthdate. This crosswalk file was used to identify ARIC cohort participants eligible for CMS Medicare coverage. The present study was focused on hospitalizations occurring during the years 2005–2009. Therefore, ARIC study participants

were included in the study if they were alive as of January 1, 2005, were 65 years of age or older on December 31, 2009, experienced a non-fatal hospitalization in the years 2005–2009, and the date of their hospitalization fell within the window of FFS eligibility.

Information concerning ARIC study participant enrollment in fee-for-service (FFS) Medicare was obtained from monthly indicators of enrollment in Part A, Part B, and Medicaid buy-in available from annual CMS Medicare Beneficiary Summary files. Continuous enrollment periods were created to indicate uninterrupted CMS Medicare FFS coverage, defined as enrollment in CMS Medicare Part A and Part B and lack of enrollment in a Medicare Advantage (HMO) plan. Study participants with gaps in coverage resulting from discontinuation of enrollment, enrollment in a Medicare Advantage plan, or from missing enrollment information and those with continuous Medicare Advantage enrollment were excluded from the study. The final study population was 6249 ARIC cohort members.

Event ascertainment

Hospitalized HF events were identified from the CMS Medicare Provider Analysis and Review (MedPAR) file and from the linked ARIC medical records using the ICD-9-CM code 428.x as well as the HF diagnostic ICD-9-CM codes identified by the Chronic Conditions Data Warehouse (CCW) in the specification of the HF algorithm[8] (ICD-9-CM codes: 398.91, 402.01, 402.11, 402.91, 404.01, 404.11, 404.91, 404.03, 404.13, 404.93, 428.x). Clinical diagnostic categories for all hospitalizations were determined using the Clinical Classification Software obtained from the Healthcare Cost and Utilization Project (HCUP).

Classification of HF events

Classification of HF hospitalization, identified through ARIC surveillance as definite or possible acute decompensated HF and chronic stable HF is based on review of medical records, including history and physical examination, echocardiography data, nuclear reports, three chest X-ray reports, catheterization report, laboratory assays and the discharge summary[3]. Information obtained from medical records is also used to classify HF events according to the Framingham[4], Modified Boston[5], NHANES[6], and Gothenburg[7] criteria (detailed HF classification criteria are provided in the online Appendix).

Evaluation of agreement in the identification of HF events from ARIC medical records and the CMS Medicare claims

To examine the agreement in discharge data, ARIC hospitalization records for the years 2005–2009 meeting FFS eligibility criteria were linked with CMS Medicare MedPAR data for FFS hospitalizations occurring during the same observation period. The unique ARIC cohort ID and date of discharge were used as the linkage variables. Distinct hospitalization records present in both data sources and those present only in the MedPAR records as well as those present only in the ARIC medical records were identified.

Concordance of heart failure diagnostic ICD-9-CM codes for hospitalizations present in both data sources was evaluated separately for the ICD-9-CM code 428.x and for the CCW HF-specific codes. Concordance was examined for codes in any position and as primary

diagnosis codes. While medical records of hospitalizations in the ARIC Study allow for up to 26 diagnostic codes, the MedPAR records for the years up to 2009 allow for only a maximum of 10 diagnostic codes in the record. Concordance of HF diagnostic codes obtained from the CMS Medicare records with HF diagnostic codes obtained from ARIC medical records was examined using all possible CMS MedPAR and ARIC medical record diagnostic codes. To achieve comparability of records, a sensitivity analysis was performed in which ARIC medical record diagnostic codes were limited to the first 10 codes.

Accuracy of CMS Medicare data in identification of decompensated HF

Hospitalized HF events are classified in ARIC[3] as acute decompensated HF (ADHF) or chronic stable HF using criteria based on medical history, symptom presentation, information on symptom onset, results of diagnostic tests, and medication use. Additionally, ARIC provides classification of hospitalized HF events according to the Framingham[4], Modified Boston[5], NHANES[6], and Gothenburg[7] criteria (detailed information concerning these HF classification schemes is provided in the Appendix). Sensitivity, specificity, and the positive and negative predictive values of HF ICD-9-CM diagnostic codes found in CMS Medicare MedPAR records were examined for HF classified according to the ARIC classification criteria as ADHF or ADHF plus chronic stable HF. Additionally, the positive predictive values of HF diagnostic codes found in the CMS Medicare MedPAR records were examined in relation to HF classified according to Framingham, Modified Boston, NHANES, and Gothenburg criteria. Estimates of the positive predictive value were compared with prevalence of HF set at 15%. Bayes' theorem[9] was applied to provide estimates of the positive predictive value of ICD-9-CM HF-specific codes from CMS MedPAR records in the identification of acute decompensated or chronic stable HF for prevalence of HF ranging from 10% to 35%.

RESULTS

Matching of hospitalization records between ARIC and CMS Medicare

A flow diagram describing the matching of hospitalizations for which information was available from CMS MedPAR records and from ARIC medical records is presented in Figure 1. Briefly, a total 15,275 hospitalized events, occurring among 5,268 cohort participants during the years 2005–2009, were identified from the CMS Medicare MedPAR files. Excluded from analyses were records for skilled nursing facility stays (SNF; n=1,896) and all records which did not fit the pre-specified criteria of fee-for-service care (n=2,309), leaving 11,070 MedPAR records which fit FFS eligibility criteria for events occurring among 4,216 ARIC cohort participants. For that same period, information concerning 13,557 hospitalized events for 5,686 ARIC cohort participants was abstracted for review from hospital medical records. Of those, 9,205 events, occurring among 3,863 ARIC cohort participants, fit criteria of CMS Medicare FFS eligibility.

Identified FFS CMS MedPAR records were linked by unique participant ID and discharge date with ARIC Study hospital medical records meeting FFS criteria. We observed a perfect match for 8,109 FFS hospitalizations occurring among 3,538 cohort participants. Additional, imperfect matching of the ARIC cohort participant IDs and discharge dates was obtained for

123 FFS hospitalizations, occurring among 115 study participants, by allowing the dates of discharge observed in the ARIC data and those obtained from the CMS MedPAR records to vary by 7 days or less (n=90 observations) or by 8–30 days (n=33 observations). Discharge dates differing by 365 days for 7 FFS hospitalized events occurring among 7 study participants were also included in the analyses. The total number of matched discharge dates for FFS hospitalizations was 8,239, occurring among 3,578 ARIC study participants (68.5% match).

We observed 2,831 FFS hospitalizations occurring among 1,633 study participants for which hospitalization information was available only from the CMS Medicare MedPAR records and 966 hospitalizations (among 702 study participants) in the ARIC medical records for which there was no corresponding record in the CMS MedPAR records despite CMS Medicare FFS eligibility.

Although differences in demographic characteristics and baseline comorbidity levels were observed between participants with healthcare records in the three above-mentioned categories (matched records, ARIC-only records, and CMS-only records) no discernible patterns were noted in any of those characteristics (Table 1). Differences were also observed in the pattern of clinical diagnostic groups in ARIC medical records as compared to CMS claims (Table 2). Those differences were more pronounced when examining clinical diagnostic groups based on ICD-9-CM codes in the primary position as compared to codes in any position. Primary diagnostic codes identifying diseases of the circulatory system were consistently less prevalent in CMS MedPAR records as compared with ARIC medical records, independent of record match. Consistent with differences in coding observed for the overall category of circulatory diseases, the proportion of HF events identified from CMS MedPAR records using any of the four HF classification schemes was lower than the proportion of HF events so identified from ARIC medical records.

Concordance of HF diagnostic codes

Agreement for HF-specific codes found in ARIC discharge records and in CMS MedPAR records was ascertained for the FFS hospitalizations which matched on participant ID and discharge date (Table 3). The high kappa coefficient values observed for CCW HF ICD-9-CM codes (κ=0.92 (95%CI 0.91, 0.93)) or ICD-9-CM code 428.x (κ=0.92 (95%CI 0.91, 0.93)) in any position, was attenuated in analyses limited to codes in the primary position (CCW codes: κ=0.77 (95% CI 0.74, 0.80) and ICD-9-CMS code 428.x: κ=0.80 (95% CI 0.77, 0.83)). The observed concordance did not change appreciably when the number of ARIC Study diagnostic codes was limited to the first 10 codes listed in the medical record (ICD-9-CM code 428.x k=0.78).

The kappa coefficient is subject to prevalence bias, such that very low or very high prevalence of the estimated value may lead to erroneously low kappa values. The prevalence-adjusted and bias-adjusted kappa (PABAK) coefficients[10] accounted for the low prevalence (<5%) of the HF-specific primary diagnoses codes and increased the agreement between CMS Medicare and ARIC Study hospitalization records for HF-specific ICD-9-CM codes in the primary position.

In examining differences in the kappa coefficient of agreement for the HF ICD-9-CM codes found in CMS Medicare and ARIC discharge records by gender and race, we observed a slightly greater agreement among men as compared to women. Agreement between the HF-related ICD-9-CM codes was likewise greater for blacks as compared to whites. Observed differences were, however, not statistically significant (data not shown).

Validity of CMS Medicare data in the identification of acute decompensated and chronic stable HF

For both CMS Medicare and ARIC records, sensitivity of ICD-9-CM codes in relation to ARIC classification of events as acute decompensated HF or as combined acute decompensated HF or chronic stable HF decreased for primary diagnosis codes as compared to codes present in any position (Table 4). This decrease in sensitivity was paired with an increase in positive predictive value, reflecting a decrease in the proportion of events identified as HF on the basis of the ICD-9-CM diagnostic codes. The greater sensitivity of HF diagnostic codes obtained from ARIC medical records in comparison with codes obtained from CMS MedPAR records in the identification of acute decompensated and chronic HF hospitalizations was not statistically significant.

A comparison of positive predictive value (PPV) for HF diagnostic codes according to multiple classification schemes, including the ARIC, Framingham, Modified Boston, NHANES and Gothenburg criteria is presented in Appendix Table 2. The PPV of HF diagnostic codes found in any position with respect to all HF classification schemes was similar between ARIC and CMS records. The PPV of HF diagnostic codes found in the primary position was consistently greater for codes found in CMS MedPAR records as compared to codes found in ARIC medical records, regardless of the HF classification scheme. The positive predictive value of the ICD-9-CM HF diagnostic codes found in the CMS Medicare hospitalization claims and in the ARIC medical records increased with increase in HF prevalence (Appendix, Table 3). The observed validity of the HF diagnostic codes in the identification of HF events did not change appreciably from 2005 to 2009 (data not shown).

DISCUSSION

Healthcare claims provide an opportunity to enhance the understanding of trends in HF prevalence and incidence beyond that available from limited population-based data. However, to achieve reliable estimates, an assessment of the extent to which the HF diagnostic codes available from the claims data accurately identify HF events is needed.

In a recent systematic review of methods used to identify HF hospitalizations, Saczynski et al[11] conclude that use of ICD-9-CM code 428.x as the primary discharge diagnosis in administrative claims yields a high positive predictive value in comparison with information on HF incidence available from medical records. We sought to extend those findings to examine the validity of hospitalized HF events identified on the basis of ICD-9-CM codes obtained from CMS Medicare hospitalized claims in the identification of HF classified according to multiple established criteria.

We first examined the match between hospital discharges records available from medical records for participants of the ARIC Study cohort with hospitalization records found in linked CMS Medicare data. We observed that only 68% of records meeting FFS criteria, and therefore eligible to be found in both sources of data, matched on date of service and participant ID. A considerable proportion of FFS records (24%) was found only in CMS Medicare data, whereas 8% of those records were available only from ARIC hospitalization record abstraction. Other hospitalizations for ARIC cohort participants were not available from CMS Medicare data due to lack of CMS Medicare enrollment or lack of FFS eligibility (39% of all hospitalization records). These proportions did not differ by years of the period of observation (2005–2009), nor were they limited to specific ARIC study sites. Our observations underscore caveats inherent in the comparison of hospital billing records with information based on abstraction of medical records.

Although the ARIC study makes every attempt to capture all hospitalized events, study participants may fail to recall a hospital admission recorded as a CMS Medicare claim. Some study participants seasonally change their place of residence and seek care outside of the geographically defined active surveillance areas which makes complete retrieval of hospital records more difficult. By design, the ARIC surveillance of hospitalized events does not currently capture hospital stays that are shorter than 24 hours, inpatient rehabilitation services, or hospice care and it is possible that records found only in CMS Medicare data originated with those services. The smaller proportion of hospitalization records present only in the ARIC medical records could have resulted from participants' use at the time of hospitalization of insurance other than CMS Medicare, despite complete enrollment eligibility.

To our knowledge, this is a first attempt to at a systematic comparison of hospitalization records from an observational study with information on hospitalizations available from linked administrative claims. Our results point not only to limitations in event ascertainment due to enrollment of study participants in managed care programs, but also to discrepancies in the recording of events that should have otherwise been present in both data sources.

We observed a high level of agreement between HF diagnostic codes for hospitalized events found in CMS MedPAR records and those available from linked medical records. The concordance of discharge codes between the two sources, estimated using the kappa statistic, decreased in analyses limited to codes in the primary position. These observations were not altered appreciably in analyses stratified by gender or by race, nor when the codes in the ARIC medical records were limited to the first ten positions to provide comparability with notations found in CMS MedPAR records. The concordance of the HF diagnostic codes was consistent over the years of observation.

Heart failure is classified in the ARIC study as possible or probable acute decompensated, and as chronic stable heart failure on the basis of pre-specified criteria, which are applied to the review of hospital medical records. This unique differentiation between chronic HF hospitalizations and hospitalizations for acute decompensated HF events, not available from other established HF classification schemes, allows for a more accurate assessment of the underlying causes of HF-related hospitalizations[3].

Considering the ARIC HF classification criteria as the referent “gold standard”, we found that the sensitivity of HF diagnostic codes from CMS Medicare claims in the identification of acute decompensated and chronic stable HF events was low, especially for the primary diagnostic codes, reflecting the diagnostic complexity of heart failure-related hospitalizations. The positive predictive value of the HF diagnostic codes, that is, the extent to which events identified on the basis of codes could be classified as acute decompensated or chronic stable HF events, was greater for codes in the primary position, as compared to codes in any position. Coupled with the observed lower sensitivity of the diagnostic codes in the primary position compared with that of codes in any position, and the variation of the positive predictive value with HF prevalence, these observations suggest that HF diagnostic codes in any position, as compared to primary diagnoses, provide a more accurate way to identify acute decompensated HF events from CMS Medicare hospitalization records. The precision with which HF events can be classified as acute decompensated HF depends greatly on HF prevalence and is greater for codes in the primary, as compared to any, position.

The observed differences in the positive predictive value of primary diagnostic codes found in CMS Medicare data as compared to the primary diagnostic codes from the ARIC hospitalization records suggest the presence of “rule-out” HF diagnoses in CMS Medicare claims. A greater proportion of codes in non-primary position for pneumonia, anemia, COPD and acute and chronic kidney disease which we found in CMS Medicare in comparison with ARIC medical records (data not shown) would substantiate that finding.

As documented by Saczynski et al[11], considerable variation exists in the manner in which HF events have been identified from medical records and used to validate HF identification from administrative claims. Standards used in the published algorithms range from established HF classification schemes to a single listing of a HF diagnosis in a medical chart. The present study contributes to the existing literature on identification of hospitalized HF events on the basis of administrative claims data by providing systematic estimates of the accuracy of the HF diagnostic codes based on established and validated HF classification criteria. Our results help to understand the potential caveats when HF hospitalizations are identified from CMS Medicare data and used to make inferences concerning HF diagnosis, treatment and prognosis.

Study Limitations

Several limitations of this study should be noted. This study is focused on the validity of HF diagnostic codes found in CMS Medicare records, and as such does not speak to the generalizability of findings to other administrative health records. Further, analyses were based exclusively on information available for fee-for-service encounters in records that matched on ID and date of service, potentially limiting generalizability of study findings to non-fee-for-service Medicare services. Until the year 2010, CMS Medicare limited to ten the number of diagnostic codes present in MedPAR records. Analyses for this study were performed with data for the years 2005–2009, during which the number of available codes from ARIC medical records was greater than those available from MedPAR records. Although a sensitivity analyses limited to the first 10 codes from the ARIC medical record

did not change estimates, the more limited number of diagnostic codes in the CMS MedPAR records could have contributed to the overall low positive predictive value in the identification of HF events from HF diagnostic codes found in claims. Lastly, placement of diagnostic codes in administrative claims is dictated by billing practices. Therefore, this comparison of ICD-9 codes found in administrative claims to codes obtained from medical records may be open to reporting bias if billing practices influenced the choice and/or placement of diagnostic codes.

Conclusion

Results of this study suggest that significant differences exist in the manner in which hospitalizations are recorded in administrative claims as compared to medical records, and that those differences extend beyond criteria of eligibility for insurance reimbursement, such as Medicare fee-for service. Careful assessment of completeness and quality of record match should be performed when using administrative claims linked with other hospitalization records. We observed that identification of hospitalized patients with HF using CMS Medicare diagnostic codes was comparable to that based on diagnostic codes available from medical records. However, low sensitivity may limit the accurate identification of acute decompensated HF events solely on the basis of CMS Medicare diagnostic codes.

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A. Classification schemes for hospitalized heart failure events

1. Framingham Criteria

Heart failure is present with 2 major or 1 major plus 2 minor criteria:

Major criteria: Paroxysmal nocturnal dyspnea or oorthopnea, neck vein distension, rales, cardiomegaly, acute pulmonary edema, S3 gallop, increase venous pressure (≥= 16 cm H_20), circulation time ≥=25 seconds, hepatojugular reflux)

Minor criteria: Ankle edema, night cough, dyspnea on exertion, hepatomagaly, pleural effusion, vital capacity decreased one third from maximum, tachycardial heart rate (≥=120/min); weight loss ≥= 4.5 kg in 5 days in response to treatment (major criterion if weight loss occurred during therapy, otherwise minor).

2. Modified Boston Criteria

Classification based on a point system (8–12 points definite HF, 5–7 points possible HF, < 5 HF unlikely) assessed according to the following three categories. No more than 4 points allowed for each of the categories.

Category I: History: No dyspnea (0 pts), leg fatigue on walking on level (1 pt), dyspnea walking on level (2 pts), paroxysmal nocturnal dyspnea (3 pts), orthopnea (4 pts), dyspnea at rest (4 pts).

Category II: Physical findings: Heart rate < 90 (0 pts), 91–110 (1 pt), > 110 (2 pts); Jugular venous pressure: < 6 cm H_20 (0 pts), > 6 cm H_20 (2 pts), > 6 mm H_20 plus liver enlargement or pitting edema (3 pts);Pulmonary rales: No (0 pts), at the bases only (1pt), more than basilar (2 pts); Wheezes: No (0 pts), yes (3 pts); S3 gallop: No (0 pts), yes (3 pts)

Category III: Clinical tests: Chest X-ray - normal (0 pts), upper flow redistribution (2 pts), cardiac enlargement (relative heart volume>540 ml.m-2 in men and > 490 ml m-2 in women) (3 pt), interstitial pulmonary edema (3 pts), bilateral pleural effusion (3 pts), alveolar pulmonary edema (4 pts)

3. NHANES Criteria

Classification based on a point system (HF present if score ≥=3):

History: Shortness of breath when hurrying on the level or up slight hill (1 pt), shortness of breath when walking at ordinary pace on the level (1pt), stops for breath when walking at own pace (2 pts), stops for breath after 100 yards on the level (2 pts)

Physical exam: Heart rate 91–110 (1pt), > 110 (2 pts), basal rales (1pt), > basal rates (2 pts), neck vein distension (1pt), neck vein distention and edema or hepatomegaly (2 pts)

Chest x-ray: cephalization of pulmonary veins (1pt), interstitial edema (2pts), alveolar fluid and pleural fluid (3 pts), interstitial edema and pleural fluid (3 pts)

4. Gothenburg Criteria

Takes into account history and physical findings to calculate a composite score based on three separate scores.

Grade 0 (absent) if all 3 scores are 0.

Grade 1 (latent) if cardiac score > 0 and pulmonary and therapy score = 0.

Grade 2 (manifest HF) if cardiac score > and either pulmonary or therapy score > 0.

Grade 3 heart failure if cardiac score > 0 and both pulmonary and therapy score > 0.

Grade 4 if the person died in HF.

Cardiac score: Coronary heart disease present in past (1 pt), present within last year (2 pts); angina pectoris present in the past (1 pt), present within last year (2 pts); swollen legs at end of day (1 pt); pulmonary rales at physical exam (1 pt); atrial fibrillation on ECG (1 pt). Note heart disease and angina can only contribute 2 points together.

Pulmonary disease score: History of chronic bronchitis (1 pt), history of chronic bronchitis within last year (2 pts); history of asthma (1 pt), history of asthma within last year (2 pts); history of coughing, phlegm or wheezing (1 pt), presence of rhonchi at physical examination (1 pt).

Therapy score: History of digitalis administration (1 pt), history of diuretic administration (1 pt).

5. ARIC Study HF Classification Criteria

Study participants' hospitalization records are reviewed for evidence of the following symptoms of HF: new onset or worsening shortness of breath, peripheral edema, paroxysmal dyspnea, orthopnea, hypoxia, HF as a cause for hospitalization. In the presence of such evidence, a detailed abstraction of the medical record is completed. Heart failure is classified

as acute decompensated heart failure (definite and possible) or as chronic stable heart failure.

Acute Decompensated HF (ADHF)

Definite ADHF: evidence either from symptoms, signs, imaging, or treatment of an acute exacerbation, worsening or new onset of symptoms, or other decompensated circulatory state, including augmentation of therapy for worsening HF signs or symptoms, documentation of subsequent in-hospital control of symptoms by therapy, documentation of the specificity of HF for decompensated state as opposed to other comorbidities (eg, chronic obstructive pulmonary disease [COPD], end-stage renal disease). Evidence that the HF treatment (eg, diuresis) is the main treatment that resulted in improvement of symptoms.

Possible ADHF: acute decompensated HF occurring in the presence of comorbidity, such that the comorbidity could account for the acute symptoms or if there is not enough information to classify the event as definite ADHF.

Chronic Stable HF

Evidence of compensated HF signs and symptoms controlled by therapy with no evidence of therapy augmentation or symptom worsening during the hospitalization.

Appendix Table 1

Positive predictive value (%) of ICD-9-CM HF codes in the classification of HF from matched ARIC hospitalization records and CMS MedPAR records. The ARIC Study cohort 2005–2009.

Diagnostic codes for hospitalized HF in CMS MedPAR records	codes in any position		codes in primary position	
	ARIC	CMS	ARIC	CMS
	HF classified according to ARIC criteria as acute decompensated HF			
ICD-9-CM code 428.x	42.14 (40.42, 43.87)	42.19 (40.35, 44.05)	56.71 (52.69, 60.64)	68.6 (63.99, 72.87)
CCW ICD-9-CM HF codes	41.86 (40.18, 43.57)	42.24 (40.43, 44.07)	66.47 (62.16, 70.53)	66.47 (62.16, 70.53)
	HF classified according to Framingham criteria			
ICD-9-CM code 428.x	48.81 (46.81, 50.82)	47.56 (45.46, 49.67)	57.5 (53.04, 61.84)	64.99 (59.61, 70.01)
CCW ICD-9-CM HF codes	48.29 (46.33, 50.26)	47.6 (45.53, 49.68)	56.4 (52.8, 59.94)	64.52 (59.53, 69.21)
	HF classified according to Modified Boston criteria			
ICD-9-CM code 428.x	47.16 (45, 49.34)	55.59 (51.03, 60.06)	60.55 (55.05, 65.81)	47.16 (45, 49.34)
CCW ICD-9-CM HF codes	47.09 (44.96, 49.23)	58.41 (54.37, 62.35)	59.95 (54.85, 64.85)	47.09 (44.96, 49.23)
	HF classified according to NHANES criteria			
ICD-9-CM code 428.x	47.08 (44.89, 49.27)	54.94 (50.35, 59.44)	59.8 (54.25, 65.12)	47.08 (44.89, 49.27)
CCW ICD-9-CM HF codes	46.98 (44.82, 49.15)	55.71 (51.59, 59.76)	58.86 (53.72, 63.81)	46.98 (44.82, 49.15)

Diagnostic codes for hospitalized HF in CMS MedPAR records	codes in any position		codes in primary position	
	ARIC	CMS	ARIC	CMS
	HF classified according to Gothenburg criteria			
ICD-9-CM code 428.x	60.42 (57.67, 63.11)	69.57 (64.09, 74.54)	74.9 (68.42, 80.44)	60.42 (57.67, 63.11)
CCW ICD-9-CM HF codes	60.16 (57.45, 62.81)	54.59 (50.46, 58.67)	74.46 (68.44, 79.68)	60.16 (57.45, 62.81)

Appendix Table 2

Positive predictive value of ICD-9-CM HF codes from CMS Medicare hospitalization claims with respect to the identification hospitalized HF events*

Diagnostic codes for hospitalized HF in CMS MedPAR records	Prevalence	Positive predictive value, %	
		codes in any position	codes in primary position
ICD-9-CM code 428.x	10%	32.3	58.9
CCW ICD-9-CM HF codes	10%	32.3	56.8
ICD-9-CM code 428.x	15%	43.1	69.5
CCW ICD-9-CM HF codes	15%	43.1	67.6
ICD-9-CM code 428.x	20%	51.7	76.4
CCW ICD-9-CM HF codes	20%	51.7	74.7
ICD-9-CM code 428.x	25%	58.8	81.2
CCW ICD-9-CM HF codes	25%	58.8	79.8
ICD-9-CM code 428.x	30%	64.8	84.7
CCW ICD-9-CM HF codes	30%	64.8	83.5
ICD-9-CM code 428.x	35%	69.8	87.4
CCW ICD-9-CM HF codes	35%	69.8	86.4

*HF was classified according to the ARIC classification criteria as acute decompensated or chronic stable HF.

Highlights

- Hospitalization records from CMS Medicare do not match completely on beneficiary ID and date of service with abstracted medical records.
- Within records that match on beneficiary ID and date of service, heart failure diagnostic codes from CMS Medicare and medical records show excellent agreement
- CMS Medicare data may over-estimate the occurrence of hospitalized HF

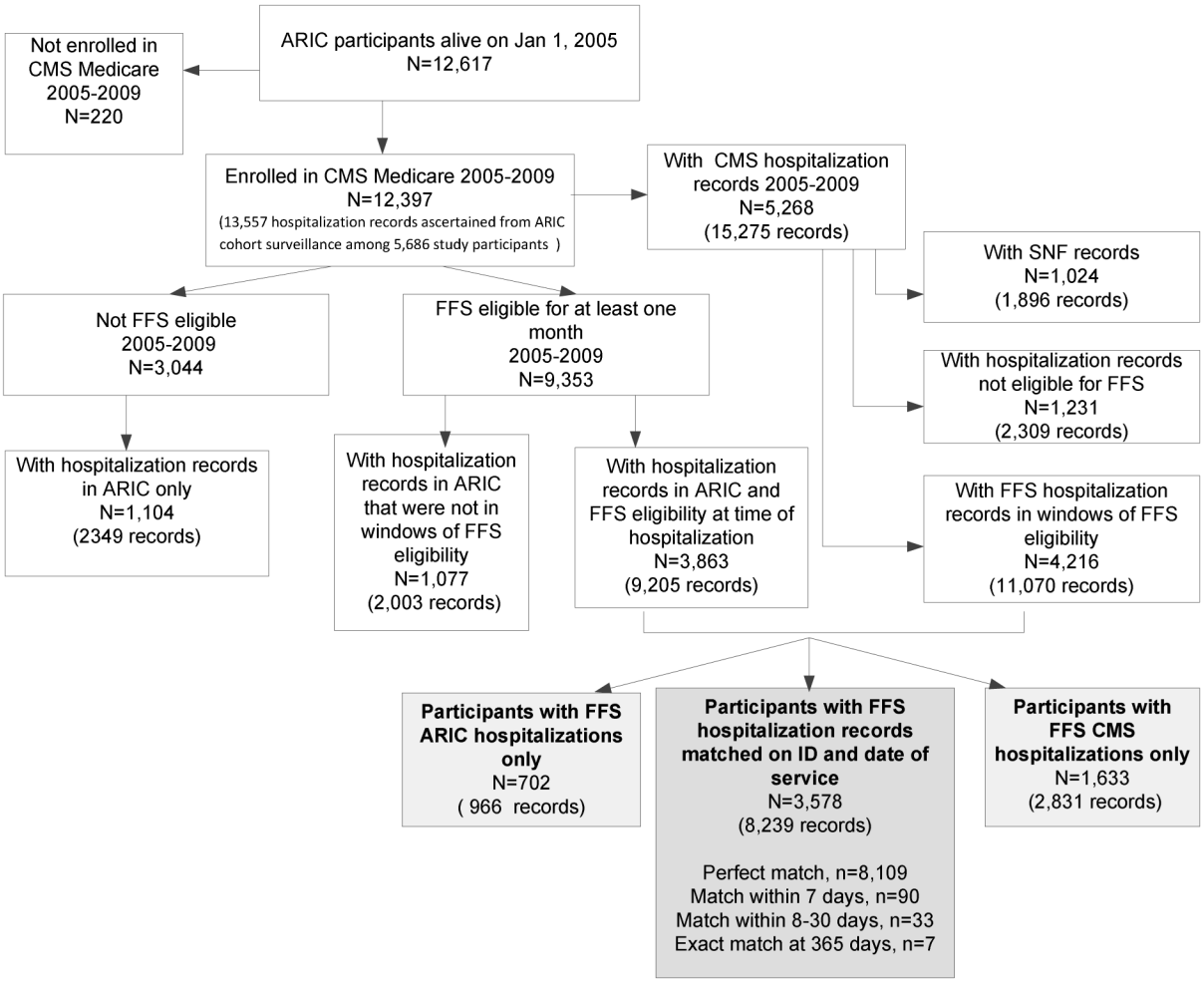

Figure 1.
Hospitalizations found in linked ARIC and CMS Medicare records

Table 1

Characteristics of study participants with records of FFS hospitalizations occurring in years 2005–2009. The ARIC Study cohort.

Characteristic	Participants with matched ARIC and CMS discharge records (n=8,239)	Participants with non- matched records		*p-value*[*]
		ARIC records only (n=966)	CMS records only (n=2,831)	
Demographics, % (unless otherwise stated)				
Age at time of hospitalization, years (SD)	74.3 (5.5)	73.5 (5.9)	74.0 (5.6)	<0.01
Gender, men	42.7	56.3	41.0	<0.01
Race, black	26.9	29.3	27.2	0.02
Comorbidities, % (unless otherwise stated)				
Baseline hypertension	40.0	34.0	33.8	<0.01
Baseline diabetes	13.8	10.7	10.8	<0.01
Baseline smoking status, never	41.9	36.6	42.3	0.04
Baseline BMI, kg/m^2 (SD)	28.6 (5.6)	27.3 (4.9)	27.9 (5.4)	<0.01
Baseline HDL-cholesterol, mg/dL (SD)	50.1 (16.2)	52.1 (17.4)	53.3 (17.3)	<0.01
Baseline LDL-cholesterol, mg/dL (SD)	141.2 (39.9)	137.3 (39.1)	138.3 (37.5)	0.06
Baseline triglycerides, mg/dL (SD)	137.5 (89.7)	136.9 (113.7)	126.7 (79.4)	0.03

[*] p-values for the comparison across the three match categories (matched records, ARIC-only records, CMS-only records) were obtained using analysis of variance for continuous variables and chi-square tests for categorical variables

Table 2

Frequencies of clinical diagnostic code categories found in CMS FFS MedPAR records linked with ARIC cohort hospitalization records. The ARIC Study cohort 2005–2009.

	** Hospitalizations matching on discharge dates (n=8,239)		Non-matched hospitalizations (n=3,797)	
Clinical diagnostic categories	**ARIC hospitalization records**	**CMS hospitalization records**	**ARIC hospitalization records only (n=966)**	**CMS hospitalization records only (n=2,831)**
ICD-9-CM codes in any position				
Circulatory diseases Heart failure	30.4	30.01	25.57	27.01
ICD-9-CM code 428.x	22.15	20.35	20.75	16.60
CCW ICD-9-CM HF codes	22.62	20.75	16.60	16.92
Respiratory diseases	4.82	8.17	5.18	7.04
Mental disorders	3.39	3.72	5.32	5.39
Musculoskeletal diseases	4.36	5.45	4.35	6.46
Neoplasms	2.96	3.94	3.02	4
Other	54.07	48.71	56.56	50.11
ICD-9-CM codes in primary position				
Circulatory diseases Heart failure	43.81	30.25	18.81	11.09
ICD-9-CM code 428.x	6.38	4.72	3.81	3.14
CCW ICD-9-CM HF codes	7.69	5.42	4.12	3.32
Respiratory diseases	9.02	13.04	4.38	5.42
Mental disorders	1.03	1.64	1.6	2.21
Musculoskeletal diseases	7.14	9.52	2.89	4.57
Neoplasms	5.06	6.81	2.42	3.41
Other	33.92	38.74	69.9	73.3

* Chronic Conditions Data Warehouse (CCW) HF ICD-9-CM codes: 398.91, 402.01, 402.11, 402.91, 404.01, 404.11, 404.91, 404.03, 404.13, 404.93, 428.x

Table 3

Pair-wise concordance of heart failure (HF) ICD-9-CM discharge codes between CMS MedPAR records and ARIC discharge records. The ARIC Study cohort 2005–2009

		Codes in any position	Codes in primary position
Kappa coefficient (95% CI)	ICD-9-CM code 428.x	0.92 (0.91, 0.93)	0.80 (0.77, 0.83)
	CCW ICD-9-CM HF codes *	0.92 (0.91, 0.93)	0.77 (0.74, 0.80)
PABAK§	ICD-9-CM code 428.x	0.95	0.96
	CCW ICD-9-CM HF codes	0.95	0.95

* Chronic Conditions Data Warehouse (CCW) HF ICD-9-CM codes: 398.91, 402.01, 402.11, 402.91, 404.01, 404.11, 404.91, 404.03, 404.13, 404.93, 428.x

§ Prevalence and Bias Adjusted Kappa coefficient

Table 4

Sensitivity, specificity, and positive and negative predictive values of ICD-9 code 428 from CMS Medicare MedPAR records and ARIC Study hospitalization records in identification of acute decompensated and chronic stable HF. The ARIC Study cohort 2005–2009

	MedPAR		ARIC	
	ICD-9 codes in any position	**ICD-9 codes in primary position**	**ICD-9 codes in any position**	**ICD-9 codes in primary position**
Acute decompensated HF				
Sensitivity, %	56.8 (54.1, 59.6)	21.3 (19.1, 23.7)	61.8 (59.0, 64.4)	23.8 (21.5, 26.3)
Specificity, %	86.3 (85.4, 87.1)	98.3 (97.9, 98.6)	85.0 (84.2, 85.9)	96.8 (96.3, 97.2)
PPV, %	42.8 (40.4, 45.2)	69.2 (64.3, 73.7)	42.8 (40.5, 45.1)	57.3 (53.0, 61.6)
NPV, %	91.7 (91, 92.4)	87.3 (86.6, 88.1)	92.5 (91.8, 93.1)	87.5 (86.8, 88.3)
Acute decompensated HF or chronic stable HF				
Sensitivity, %	58.7 (56.4, 60.9)	18.1 (16.4, 19.9)	63.3 (61.4, 65.7)	21.5 (19.7, 23.4)
Specificity, %	91.3 (90.6, 92.0)	99.4 (99.1, 99.5)	90.5 (89.8, 91.2)	98.3 (97.9, 98.6)
PPV, %	67.4 (65.1, 69.7)	89.7 (86.3, 92.6)	67.2 (65.0, 69.4)	79.0 (75.3, 82.5)
NPV, %	87.9 (87.0, 88.6)	79.9 (79.0, 80.8)	89.1 (88.3, 89.8)	80.4 (79.5, 81.3)

PPV: positive predictive value; NPV: negative predictive value

To enable comparisons between ARIC and CMS MedPAR classifications ADHF prevalence was set at 15%