MINI-SENTINEL SYSTEMATIC EVALUATION OF HEALTH OUTCOME OF INTEREST DEFINITIONS FOR STUDIES USING ADMINISTRATIVE DATA

CONGESTIVE HEART FAILURE

Prepared by: Jane Saczynski, PhD,1 Susan Andrade, ScD,1 Leslie Harrold, MD, MPH,1 Jennifer Tjia, MD, MSCE,1 Sarah Cutrona, MD,1 Robert Goldberg, PhD,1 Jerry Gurwitz, MD1

Author Affiliations: 1. University of Massachusetts Medical School / Meyers Primary Care Institute, Worcester, MA

December 19, 2010

Mini-Sentinel is a pilot project sponsored by the U.S. Food and Drug Administration (FDA) to inform and facilitate development of a fully operational active surveillance system, the Sentinel System, for monitoring the safety of FDA-regulated medical products. Mini-Sentinel is one piece of the Sentinel Initiative, a multi-faceted effort by the FDA to develop a national electronic system that will complement existing methods of safety surveillance. Mini-Sentinel Collaborators include Data and Academic Partners that provide access to health care data and ongoing scientific, technical, methodological, and organizational expertise. The Mini-Sentinel Coordinating Center is funded by the FDA through the Department of Health and Human Services (HHS) Contract number HHSF223200910006I.
Mini-Sentinel Systematic Evaluation Of Health Outcome Of Interest Definitions
For Studies Using Administrative Data

Congestive Heart Failure Report

I. EXECUTIVE SUMMARY.............................................................................................................................................. 4
   A. OVERVIEW OF PROJECT............................................................................................................................................. 4
   B. SUMMARY OF FINDINGS............................................................................................................................................ 4
   C. RECOMMENDATION FOR ALGORITHMS AND SUGGESTION FOR FUTURE RESEARCH ...................................... 4

II. PROJECT OBJECTIVES............................................................................................................................................. 5

III. BACKGROUND ....................................................................................................................................................... 5

IV. METHODS............................................................................................................................................................... 5
   A. SEARCH STRATEGY.................................................................................................................................................... 5
   B. ABSTRACT REVIEW................................................................................................................................................ 6
      1. Abstract Review Methods....................................................................................................................................... 6
      2. Abstract Exclusion Criteria..................................................................................................................................... 6
   C. FULL-TEXT REVIEW ................................................................................................................................................ 6
      1. Full-Text Review Methods...................................................................................................................................... 6
      2. Full-Text Exclusion Criteria.................................................................................................................................... 7
   D. MINI-SENTINEL INVESTIGATOR SURVEY............................................................................................................. 7
   E. EVIDENCE TABLE CREATION.................................................................................................................................. 7
   F. CLINICIAN OR TOPIC-EXPERT CONSULTATION .................................................................................................... 7

V. RESULTS ..................................................................................................................................................................... 7
   A. SEARCH STRATEGY AND RESULTS ............................................................................................................................ 7
   B. ABSTRACT REVIEWS ................................................................................................................................................. 13
   C. FULL-TEXT REVIEWS............................................................................................................................................... 13
   D. MINI-SENTINEL INVESTIGATOR SURVEY .................................................................................................................. 14
   E. EVIDENCE INCLUDED IN TABLE ................................................................................................................................. 14
   F. SUMMARY AND DISCUSSION OF ALGORITHMS AND VALIDATION ........................................................................ 14
   G. SUMMARY OF EXCLUDED POPULATIONS AND DIAGNOSES .................................................................................. 18
   H. EVIDENCE TABLE ..................................................................................................................................................... 19
      I. CLINICIAN OR TOPIC EXPERT CONSULTATION .................................................................................................... 32

VI. SUMMARY AND CONCLUSIONS ................................................................................................................................. 33
   A. RECOMMENDATIONS FOR ALGORITHMS .................................................................................................................. 33
   B. SUGGESTIONS FOR FUTURE RESEARCH BASED ON EVIDENCE GAPS .............................................................. 33

VII. REFERENCES .............................................................................................................................................................. 34

VIII. APPENDICES ............................................................................................................................................................. 37
   A. APPENDIX A: ABSTRACTS OF STUDIES INCLUDED IN EVIDENCE TABLE ........................................................... 37
   B. APPENDIX B: LIST OF CITATIONS SELECTED FOR FULL-TEXT REVIEW BUT NOT INCLUDED, BY REASONS FOR EXCLUSION ................................................................. 54
      1. Studies Excluded Because Article Not Located/Reviewed ......................................................................................... 54
      2. Studies Excluded Because Did Not Study HOI ........................................................................................................... 54
      3. Studies Excluded Because Not Administrative Database Study .................................................................................. 55
4. Studies Excluded Because Not From the United States or Canada ............................................................59
5. Studies Excluded Due to Poorly Defined Algorithms ..............................................................................61
6. Studies Excluded Due to Lack of Validation or Reporting of Validation Statistics ..............................74
7. Studies Excluded Because Evaluated the Same Study Population as Another Study Included in the Evidence Table ...........................................................................................................................................92
C. Appendix C: List and Definitions of ICD or Procedural Codes Included in Algorithms ..................93
I. EXECUTIVE SUMMARY

A. OVERVIEW OF PROJECT

The Food and Drug Administration (FDA) Mini-Sentinel contract is a pilot program that aims to conduct active surveillance to detect and refine safety signals that emerge for marketed medical products. To perform this active surveillance, it is necessary to develop and understand the validity of algorithms for identifying health outcomes of interest in administrative data. Thus, the goal of this project was to identify algorithms used to detect selected health outcomes of interest using administrative data sources and describe the performance characteristics of these algorithms as reported by the studies in which they were used. This report summarizes the process and findings of the congestive heart failure (CHF) algorithm review.

B. SUMMARY OF FINDINGS

We found a total of 35 validation studies for heart failure (HF) to include in this report. The studies included in the report fell into a number of subgroups. Studies reported on inpatient and outpatient events, incident and prevalent outcomes, and investigations of hospitalized patients, including the evaluation of algorithms based upon primary, secondary, and all position discharge diagnoses of possible HF. In general, positive predictive values (PPVs) were in the acceptable to high range, with most being very high (>90%). The most common ‘gold standard’ for validation of HF was the Framingham Heart Study criteria for CHF. Validation of the presence of HF was almost exclusively conducted via medical chart review. In studies that focused on an incident patient population (initial events), the systematic exclusion of patients with prevalent disease identified during a specific time period (e.g., 5 years) prior to the study period improved the PPV of algorithms developed to identify newly diagnosed cases of HF.

C. RECOMMENDATION FOR ALGORITHMS AND SUGGESTION FOR FUTURE RESEARCH

Studies that included patients with a primary hospital discharge diagnosis of ICD-9 code 428.X had the highest PPV and specificity for HF. PPVs for this algorithm ranged from 84% - 100%. This algorithm, however, may compromise sensitivity since many HF patients are managed on an outpatient basis. Including outpatient codes in this algorithm would increase the sensitivity for identifying new cases of HF.

Gaps in the current literature include the need for the specific comparison of algorithms for identifying HF using inpatient as compared with outpatient diagnoses. Comparison of the validation of inpatient and outpatient algorithms against the Framingham Heart Study criteria for CHF would be most useful in order to more systematically compare the results of studies carried out in different patient populations. Algorithms also have not been validated in different age strata, particularly in elderly and very elderly patient populations with additional comorbidities, who comprise the majority of patients presenting with HF. In addition, very few validation studies have been conducted on ICD-10 codes or in patients of different race/ethnicities in whom the criteria published to date may have varying sensitivities and specificities.
II. PROJECT OBJECTIVES

The primary objective of this project was to identify studies that have validated algorithms used to identify various health outcomes of interest (HOIs) using administrative data from the United States or Canada, and to summarize the results of those validation studies. If fewer than five validation studies were identified, a secondary objective was to identify non-validated algorithms that have been used to identify the HOIs using administrative data.

III. BACKGROUND

The Food and Drug Administration (FDA) Mini-Sentinel contract is a pilot program that aims to conduct active surveillance to detect and refine safety signals that emerge for marketed medical products. In order to perform this work, the program needed to identify algorithms used to detect various health outcomes of interest using administrative data sources and identify the performance characteristics of these algorithms as measured in the studies in which they were used. The data sources of interest were limited to those from the United States or Canada to increase their relevance to the Mini-Sentinel data sources, which are all from the United States. The Mini-Sentinel Protocol Core developed a preliminary list of approximately 140 potential health outcomes of interest, based on several criteria. These criteria included: 1) previous validation studies had been identified in a textbook chapter reviewing the validity of drug and diagnosis data used in pharmacoepidemiologic studies, 2) a list of designated medical events from a proposed FDA rule on the safety reporting requirements for human drug and biological products, 3) the Observational Medical Outcomes Partnership (OMOP) had commissioned reports on algorithms used to identify the health outcome using administrative data.

From the original list of 140 HOIs, the Protocol Core worked with FDA to select 20 for which reviews of algorithms would be completed. HOIs for which OMOP had already commissioned reports were purposefully excluded in order to avoid duplication of effort.

Congestive heart failure (CHF) was one of the 20 HOIs selected for review. This report describes the review process and findings for the CHF definition algorithms.

IV. METHODS

A. SEARCH STRATEGY

The general search strategy was developed based on prior work by OMOP and its contractors, and modified slightly for these reports. Originally, OMOP contracted with two organizations to perform reviews of 10 HOIs. Because the search strategies used by each organization resulted in very different sets of articles, OMOP investigators reviewed the PubMed indexing of the articles deemed useful in final reports and developed a strategy that would identify the majority of these citations while maintaining efficiency in the number of abstracts that would need to be reviewed. Mini-Sentinel investigators made minor changes to this strategy that would result in the identification of more citations, and confirmed

---

1 For more information about OMOP see http://omop.fnih.org
empirically that the majority of relevant articles from one set of OMOP reports (angioedema)\(^4,5\) would be identified using this approach. The base search strategy was then combined with PubMed terms representing the HOIs. Medical subject heading (MeSH) terms were generally preferred as HOI search terms due to their likely specificity. Text word searches were sometimes used, particularly when the MeSH search resulted in a small number of citations for review. The workgroup also searched the database of the Iowa Drug Information Service (IDIS) using a similar search strategy to identify other relevant articles that were not found in the PubMed search. For a limited number of outcomes where very few citations were identified from PubMed and IDIS searches, Embase searches were conducted. Search results were restricted to articles published on or after January 1, 1990.

University of Iowa investigators compiled the search results from different databases and eliminated duplicate results using a citation manager program. The results were then output into two sets of files, one containing the abstracts for review and the other for documenting abstract review results.

The search strategy and results for CHF are detailed in the Results section. The PubMed search was conducted on May 7, 2010, and the IDIS searches on June 8, 2010.

B. ABSTRACT REVIEW

1. Abstract Review Methods

Each abstract was reviewed independently by two investigators to determine whether the full-text article should be reviewed. Exclusion criteria were documented sequentially (i.e. if exclusion criterion 1 was met then the other criteria were not documented). If the reviewers disagreed on whether the full-text should be reviewed, then it was selected for review. Inter-rater agreement on whether to include or exclude an abstract was calculated using a Cohen’s kappa statistic. The goal was to review any administrative database study that used data from the United States or Canada and studied the HOI, as validation components of studies are not necessarily included in the abstract and other relevant citations might be identified from the references of such studies.

2. Abstract Exclusion Criteria

1. Did not study the HOI.
2. Not an administrative database study. Eligible sources included insurance claims databases as well as other secondary databases that identify health outcomes using billing codes.
3. Data source not from the United States or Canada.

C. FULL-TEXT REVIEW

1. Full-Text Review Methods

Full-text articles were reviewed independently by two investigators, with a goal of identifying validation studies described in the article itself or from the reference section of the article. Citations from the article’s references were selected for full-text review if they were cited as a source for the HOI algorithm, or were otherwise deemed likely to be relevant. Full-text review exclusion criteria were applied sequentially, since if fewer than 5 validation studies were identified, up to 10 of the articles excluded based on the second criterion would need to be incorporated into the final report. If there was
disagreement on whether a study should be included, the two reviewers attempted to reach consensus on inclusion by discussion. If the reviewers could not agree, a third investigator would be consulted to make the final decision.

2. Full-Text Exclusion Criteria

   1. Poorly described HOI identification algorithm that would be difficult to operationalize (i.e., the algorithm could not be replicated because it was not clearly described or the components of the algorithm are not available in a standardized way, such as registry codes).
   2. No validation of outcome definition or reporting of validity statistics.

D. MINI-SENTINEL INVESTIGATOR SURVEY

Mini-Sentinel investigators were surveyed to request information on any published or unpublished studies that validated an algorithm to identify an HOI in administrative data. Studies that would not be excluded by one of the aforementioned criteria were included in the final report.

E. EVIDENCE TABLE CREATION

A single investigator abstracted each study for the final evidence table. The data included in the table were confirmed by a second investigator for accuracy.

F. CLINICIAN OR TOPIC-EXPERT CONSULTATION

A clinician or topic expert was consulted to review the results of the evidence table and discuss how they compare and contrast to diagnostic methods currently used in clinical practice. This included whether certain diagnostic codes used in clinical practice were missing from the algorithms, and the appropriateness of the validation definitions compared to diagnostic criteria currently used in clinical practice. A summary of this consultation was included in the results.

V. RESULTS

A. SEARCH STRATEGY AND RESULTS

The following summarizes the search results obtained from PubMed and IDIS searches. The PubMed search identified 822 citations (Table 1), and the two IDIS searches identified 95 unique citations (Table 2). The total number of unique citations from the combined searches was 862. An additional PubMed search was conducted at a later date to amend the original search strategy with names of relevant databases that were not included in the original search. This search identified 25 citations (Table 3).
### Table 1. PubMed Search Strategy and Results

<table>
<thead>
<tr>
<th></th>
<th>Search Description</th>
<th>Limits</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>#36</td>
<td>Search #6 and #35 Limits: Humans, English, Publication Date from 1990/01/01 to 2011/01/01</td>
<td>13:43:49</td>
<td>822</td>
</tr>
<tr>
<td>#35</td>
<td>Search &quot;Heart Failure&quot;[Mesh] Limits: Humans, English, Publication Date from 1990/01/01 to 2011/01/01</td>
<td>13:40:44</td>
<td>33058</td>
</tr>
<tr>
<td>#6</td>
<td>Search #5 not #4 Limits: Humans, English, Publication Date from 1980/01/01 to 2011/01/01</td>
<td>12:36:26</td>
<td>75587</td>
</tr>
<tr>
<td>#5</td>
<td>Search #2 and #3 Limits: Humans, English, Publication Date from 1980/01/01 to 2011/01/01</td>
<td>12:36:11</td>
<td>123566</td>
</tr>
</tbody>
</table>
### Table 2. IDIS Search Strategy and Results

#### Search 1: 26 results

**All fields**

"Premier" OR "Solucient" OR "Cerner" OR "Ingenix" OR "LabRx" OR "IHCIS" OR "marketscan" OR "market scan" OR "Medstat" OR "Thomson" OR "pharmetrics" OR "healthcare" OR "united healthcare" OR "UnitedHealthcare" OR "UHC" OR "GPRD" OR "general practice research database" OR "Research Database" OR "Group Health" OR "HCUP" OR "(Healthcare Cost" AND "Utilization Project") OR "(Health Care Cost" AND "Utilization Project") OR "MEPS" OR "Medical Expenditure Panel Survey" OR "NAMCS" OR "National Hospital Ambulatory Medical Care Survey" OR "National Ambulatory Medical Care Survey" OR "NHIS" OR "National Health Interview Survey" OR "Kaiser" OR "HMO Research" OR "Health Maintenance Organization" OR "HMO" OR "Cleveland Clinic" OR "Loveland" OR "Department of Defense" OR "Henry Ford" OR "(Denmark" AND "Epidemiology") OR "i3 Drug Safety" OR "i3" OR "Aetna" OR "Humana" OR "Wellpoint" OR "IMS" OR "Intercontinental Marketing Services" OR "IMS Health" OR "Geisinger" OR "GE Healthcare" OR "MQIC" OR "PHARMO" OR "Institute for Drug Outcome Research" OR "Pilgrim" OR "Puget Sound" OR "Regenstrief" OR "Saskatchewan" OR "Tayside" OR "MEMO" OR "Medicines Monitoring Unit" OR "Veterans Affairs" OR "Partners Healthcare" OR "Mayo Clinic" OR "Rochester Epidemiology" OR "Indiana Health Information Exchange" OR "Indiana Health" OR "Intermountain" OR "THIN" OR "The health improvement network" OR "blue cross" OR "health partners" OR "health plan" OR "health services" OR "Nationwide Inpatient Sample" OR "National Inpatient Sample" OR "medicaid" OR "medicare" OR "MediPlus" OR "Outcome Assessment" OR "insurance database" OR "insurance databases" OR "Data Warehouse" OR "ICD-9" OR "International statistical classification" OR "international classification of diseases" OR "ICD-10" OR "Database Management Systems" OR "Medical Records Systems, Computerized" OR "CPT" OR "Current procedural terminology" OR "drug surveillance" OR "(claims" AND "administrative") OR "(data" AND "administrative") OR "Databases, Factual" OR "Databases" OR "Medical Record Linkage" OR "ICD-9-CM" OR "ICD-10-CM" Records = 10,043

AND

**Descriptor(s):** "SIDE EF CARDIOVASCULAR 82" Not ("CASE REPORT ADULT 0" or "FDA APPROVAL PACKAGE 155" or "FDA BLACK BOX WARNING 165" or "PIVOTAL STUDY 162" or "FDA ADVISORY COMMITTEE 164" or "CASE REPORT PEDIATRIC 1" or "CASE REPORT GERIATRIC 2" or "REVIEW ADULT 6" or "STUDY NON-CLINICAL 8" or "REVIEW PEDIATRIC 21" or "REVIEW GERIATRIC 23" or "STUDY RANDOMIZE ADULT 135" or "STUDY RANDOMIZE PEDIATRIC 136" or "STUDY RANDOMIZE GERIATRIC 137" or "CROSS-OVER 144" or "META-ANALYSIS 145" or "N-OF-ONE TRIAL 146" or "PRACTICE GUIDELINE 156" or "SYSTEMATIC REVIEW 161" or "ANNOTATED BIBLIOGRAPHY 167" or "PRIORITY CLIN PRACT GUIDE 168")

AND **Abstract:** ("heart" and "failure") AND **Years:** 1990-2010

Records = 26

#### Search 2: 73 Results

**All fields**

"Premier" OR "Solucient" OR "Cerner" OR "Ingenix" OR "LabRx" OR "IHCIS" OR "marketscan" OR "market scan" OR "Medstat" OR "Thomson" OR "pharmetrics" OR "healthcare" OR "united healthcare" OR "UnitedHealthcare" OR "UHC" OR "GPRD" OR "general practice research database" OR "Research Database" OR "Group Health" OR "HCUP" OR "(Healthcare Cost" AND "Utilization Project") OR "(Health Care Cost" AND "Utilization Project") OR "MEPS" OR "Medical Expenditure Panel Survey" OR "NAMCS" OR "National Hospital Ambulatory Medical Care Survey" OR "National Ambulatory Medical Care Survey" OR "NHIS" OR "National Health Interview Survey" OR "Kaiser" OR "HMO Research" OR "Health Maintenance Organization" OR "HMO" OR "Cleveland Clinic" OR "Loveland" OR "Department of Defense" OR "Henry Ford" OR "(Denmark" AND "Epidemiology") OR "i3 Drug Safety" OR "i3" OR "Aetna" OR "Humana" OR "Wellpoint" OR "IMS" OR "Intercontinental Marketing Services" OR "IMS Health" OR "Geisinger" OR "GE Healthcare" OR "MQIC" OR "PHARMO" OR "Institute for Drug Outcome Research" OR "Pilgrim" OR "Puget Sound" OR "Regenstrief" OR "Saskatchewan" OR "Tayside" OR "MEMO" OR "Medicines Monitoring Unit" OR "Veterans Affairs" OR "Partners Healthcare" OR "Mayo Clinic" OR "Rochester Epidemiology" OR "Indiana Health Information Exchange" OR "Indiana Health" OR "Intermountain" OR "THIN" OR "The health improvement network" OR "blue cross" OR "health partners" OR "health plan" OR "health services" OR "Nationwide Inpatient Sample" OR "National Inpatient Sample" OR "medicaid" OR "medicare" OR "MediPlus" OR "Outcome Assessment" OR "insurance database" OR "insurance databases" OR "Data Warehouse" OR "ICD-9" OR "International statistical classification" OR "international classification of diseases" OR "ICD-10" OR "Database Management Systems" OR "Medical Records Systems, Computerized" OR "CPT" OR "Current procedural terminology" OR "drug surveillance" OR "(claims" AND "administrative") OR "(data" AND "administrative") OR "Databases, Factual" OR "Databases" OR "Medical Record Linkage" OR "ICD-9-CM" OR "ICD-10-CM" Records = 10,043

AND **Descriptor(s):** "SIDE EF CARDIOVASCULAR 82" Not ("CASE REPORT ADULT 0" or "FDA APPROVAL PACKAGE 155" or "FDA BLACK BOX WARNING 165" or "PIVOTAL STUDY 162" or "FDA ADVISORY COMMITTEE 164" or "CASE REPORT PEDIATRIC 1" or "CASE REPORT GERIATRIC 2" or "REVIEW ADULT 6" or "STUDY NON-CLINICAL 8" or "REVIEW PEDIATRIC 21" or "REVIEW GERIATRIC 23" or "STUDY RANDOMIZE ADULT 135" or "STUDY RANDOMIZE PEDIATRIC 136" or "STUDY RANDOMIZE GERIATRIC 137" or "CROSS-OVER 144" or "META-ANALYSIS 145" or "N-OF-ONE TRIAL 146" or "PRACTICE GUIDELINE 156" or "SYSTEMATIC REVIEW 161" or "ANNOTATED BIBLIOGRAPHY 167" or "PRIORITY CLIN PRACT GUIDE 168")

AND **Abstract:** ("heart" and "failure") AND **Years:** 1990-2010

Records = 73
| network" OR "blue cross" OR "health partners" OR "health plan" OR "health services" OR "Nationwide Inpatient Sample" OR "National Inpatient Sample" OR "medicaid" OR "medicare" OR "MediPlus" OR "Outcome Assessment" OR "insurance database" OR "insurance databases" OR "Data Warehouse" OR "ICD-9" OR "ICD-10" OR "international classification of diseases" OR "ICD-10-CM" OR "Database Management Systems" OR "Medical Records Systems, Computerized" OR "CPT" OR "Current procedural terminology" OR "drug surveillance" OR ("claims" AND "administrative") OR ("data" AND "administrative") OR "Databases, Factual" OR "Databases" OR "Medical Record Linkage" OR "ICD-9-CM" OR "ICD-10-CM" Records= 10,043

AND

Disease:

428.* (includes: FAILURE, HEART NEC; FAILURE, HEART, CONGESTIVE; FAILURE, HEART, LEFT; FAILURE, HEART, SYSTOLIC; and FAILURE, HEART, DIASTOLIC)

NOT

Descriptor(s): "CASE REPORT ADULT 0" or "FDA APPROVAL PACKAGE 155" OR "FDA BLACK BOX WARNING 165" OR "PIVOTAL STUDY 162" OR "FDA ADVISORY COMMITTEE 164" or "CASE REPORT PEDIATRIC 1" or "CASE REPORT GERIATRIC 2" or "REVIEW ADULT 6" or "STUDY NON-CLINICAL 8" or "REVIEW PEDIATRIC 21" or "REVIEW GERIATRIC 23" or "STUDY RANDOMIZE ADULT 135" or "STUDY RANDOMIZE PEDIATRIC 136" or "STUDY RANDOMIZE GERIATRIC 137" or "CROSS-OVER 144" or "META-ANALYSIS 145" or "N-OF-ONE TRIAL 146" or "PRACTICE GUIDELINE 156" or "SYSTEMATIC REVIEW 161" or "ANNOTATED BIBLIOGRAPHY 167" or "PRIORITY CLIN PRACT GUIDE 168"

AND Abstract: ("heart" and "failure") AND Years: 1990-2010

Records = 73
### Table 3. Search Strategy to Update the Original PubMed Search with Additional Database Names:
Performed on 07/06/10

<table>
<thead>
<tr>
<th>Search</th>
<th>Most Recent Queries</th>
<th>Time</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>#12</td>
<td>Search #7 AND (&quot;Heart Failure&quot;[Mesh]) Limits: Humans, English, Publication Date from 1990/01/01 to 2011/01/01</td>
<td>22:21:25</td>
<td>25</td>
</tr>
<tr>
<td>#7</td>
<td>Search #5 AND #6 Limits: Humans, English, Publication Date from 1990/01/01 to 2011/01/01</td>
<td>22:06:47</td>
<td>1579</td>
</tr>
<tr>
<td>#6</td>
<td>Search (TennCare [tiab]) OR (RAMQ [tiab]) OR (Cigna [tiab]) OR ((british columbia[tiab]) AND (health[tiab]) OR (data[tiab]) OR (database[tiab]) OR (population[tiab])) OR (CIHI [All Fields]) OR ((manitoba[tiab]) AND (center for health policy[all fields]) OR (population[tiab]) OR (health insurance[tiab])) OR (ontario[tiab]) AND (population[tiab]) OR (OHIP[tiab]) OR (registered persons database[tiab]) OR (health insurance [tiab]) OR (ICES[All Fields]) OR (Institute for Clinical Evaluative Sciences[All Fields])) OR (Alberta[tiab]) AND (health[tiab]) OR (data[tiab]) OR (database[tiab]) OR (population[tiab]) OR (Alberta Health and Wellness[All Fields])) Limits: Humans, English, Publication Date from 1990/01/01 to 2011/01/01</td>
<td>22:06:21</td>
<td>5128</td>
</tr>
<tr>
<td>#5</td>
<td>Search #4 NOT #3 Limits: Humans, English, Publication Date from 1990/01/01 to 2011/01/01</td>
<td>22:05:10</td>
<td>819148</td>
</tr>
<tr>
<td>#4</td>
<td>Search #1 NOT #2 Limits: Humans, English, Publication Date from 1990/01/01 to 2011/01/01</td>
<td>22:04:23</td>
<td>1748136</td>
</tr>
</tbody>
</table>
B. ABSTRACT REVIEWS

Of the 886 abstracts reviewed, 499 were selected for full-text review; 119 were excluded because they did not study HF, 217 were excluded because they were not administrative database studies, and 51 were excluded because the data source was not from the United States or Canada. Cohen’s kappa for agreement between reviewers on inclusion vs exclusion of abstracts was 0.65.

C. FULL-TEXT REVIEWS

Of the 498 full-text articles identified by the initial search terms (one article could not be located), 25 were included in the final evidence tables; 12 were excluded because they did not study HF, 52 were excluded because they were not administrative database studies, 25 were excluded because the data source was not from the United States or Canada, 158 were excluded because the HOI identification algorithm was poorly defined, 220 were excluded because they included no validation of the outcome...
definition or reporting of validity statistics, and 6 were excluded because they reported statistics from the same study population as another study that is included in the evidence table. Reviewers identified 40 citations for review from full-text article references. Of these, 9 were included in the final report; 2 were excluded because they did not study HF, 1 was excluded because the data source was not from the United States or Canada, 13 were excluded because the HOI algorithm was poorly defined, 14 were excluded because they included no validation of the outcome definition or reporting of validity statistics, and 1 was excluded because it was an abstract. Cohen's kappa for agreement between reviewers on inclusion vs exclusion of full-text articles reviewed was 0.83.

D. MINI-SENTINEL INVESTIGATOR SURVEY

Mini-Sentinel investigators provided 3 published and no unpublished reports of validation studies that had been completed by their teams. The 3 published reports from Mini-Sentinel investigator teams all reported on the same study sample. One article had been identified from full-text article reviews and contained the most information on validation of the 3 articles. Thus, this article was included in the review and the other two were excluded. They provided 2 published reports that they were familiar with but not directly involved in. Of the 2 published reports from other teams, 1 had been identified from full-text article reference reviews and 1 had not been previously identified through other methods.

E. EVIDENCE INCLUDED IN TABLE

Of the 35 studies included in the evidence table (Table 4), 25 were identified from the initial search strategy, 9 were identified through references of articles that underwent full-text review, and 1 was provided by Mini-Sentinel investigators.

F. SUMMARY AND DISCUSSION OF ALGORITHMS AND VALIDATION

Codes Used in Algorithms. All 35 publications listed in the evidence table used ICD-8, ICD-9, ICD-10 or DRG codes to identify patients with HF. The vast majority of included studies (n=32) used ICD-9 codes to identify patients with outpatient encounters or hospitalizations for HF. All of the studies that used ICD-9 codes included code 428.x alone or in combination with other ICD-9 codes. Other common ICD-9 codes used in the algorithms of the included studies were: 398.91, 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 425, and 429.3. See Appendix C for definitions of these HF-related codes.

Only 2 studies validated a diagnosis of HF against ICD-10 codes (So, 2006; Ezekowitz, 2008). ICD-10 code I50 was always included in the algorithms. One study (So, 2006) also included additional ICD-10 codes: I09.9, I11.0, I13.0, I13.2, I25.5, I42.0, I42.5-I42.9, I43.x, P29.0. Several studies (n=4) used DRG code 127; one study used DRG code 124 in combination with an ICD-9 code for HF.

A majority of the studies (n=27) evaluated algorithms based exclusively on hospitalizations for HF. A majority of the studies (n=28) identified both incident and prevalent cases of HF. In most studies where only incident cases were reported (n=7), patients with a previous diagnosis of HF, based on the study algorithm (e.g., 5 year period prior to the initial diagnosis during the study period), were excluded from the sample.
Validation Criteria and Method. Nearly all studies included in the report validated administrative coding data through abstraction of medical charts. Documentation of heart failure in the medical records was generally based on physician notes. Several studies specified criteria from medical records (e.g., signs, symptoms or radiographic evidence of HF; treatment with both digoxin and a diuretic; ejection fraction <40%, etc.). The most commonly used ‘standardized criteria’ used to validate algorithms was the Framingham criteria for CHF (presence of 2 major or 1 major and 2 minor criteria), which were applied in 14 studies. The Carlson criteria (≥4) were also applied in 2 studies but these studies also applied the Framingham criteria. When both the Framingham and Carlson criteria were applied, the PPVs for validation using the Framingham criteria (PPVs = 94-96%) were higher than that of the Carlson criteria (PPVs = 88-90%). The NHANES criteria (≥3) were applied in one study as a comparison to the Framingham criteria. Similar to the Carlson criteria, the NHANES criteria had a lower PPV (56%) compared to the Framingham criteria.

One study (Austin, 2002) used registry data to validate administrative claims data. Jollis, et al. and Lentine, et al. used clinical databases developed for specific patient populations (patients undergoing cardiac catheterization and kidney transplantation, respectively) to validate administrative codes. The reported estimates for sensitivity varied greatly with the different algorithms assessed in these studies. While the reported estimates for specificity in the studies by Jollis, et al. and Austin, et al. were generally quite high, the reported PPVs were quite low in the study by Austin, et al., (65% or lower). However, in this study only 14% of patients with a discharge diagnosis for HF could be linked to the registry.

Validation Algorithms. In general, differences in the PPVs for the use of ICD-9 code 428.x alone compared with its combined use with other ICD-9 codes were negligible. Nine studies reported validation statistics for ICD-9 code 428.x alone. Except for the study by Austin, et al., these studies reported high PPVs (range = 84-100%). Two studies compared the validation of ICD-9 code 428.x with other ICD-9 codes. One study (Goff 2000) directly compared the validation of ICD-9 code 428.x with other algorithms using ICD-9 428 in combination with other ICD-9 codes and reported the highest PPV for ICD-9 code 428 alone (PPV=84%), with the combination of ICD-9 428 or 402 yielding a PPV of 79% and the combination of ICD-9 428 or the presence of a number of ICD-9 codes for HF yielding a PPV of 77%. A second study (Roger, 2004) reported a PPV of 84% for ICD-9 code 428.x compared with PPVs of 14-30% for other algorithms (including ICD-9 codes 402.01, 402.11, 425, 429.3, 514) that did not include code 428.

Since few studies reported validation of ICD-10 codes, it is difficult to comment on the validation statistics between ICD-9 and 10 coding algorithms. However, one study (So, 2006) directly compared the validation of ICD-9 and ICD-10 codes for evidence of HF in the medical charts. This study found the PPV of the ICD-10 codes (I09.9, I11.0, I13.0, I13.2, I25.5, I42.0, I42.5-I42.9, I43.x, I50.x, P29.0) to be slightly higher than the PPV of the ICD-9 code 428.x (94% vs 90%).

Some studies calculated validation statistics based only on a subsample of the overall study population. In general, these subgroups were random samples of the overall study population, enhancing the validity of the corresponding statistics. However, one study (Baker, 2007) validated a diagnosis of HF only in patients who had a diagnosis of HF in their medical history but no HF encounters in the administrative data (n=28) or only had a single encounter diagnosis of HF (n=66); therefore, in this study, only ‘ambiguous’ cases were validated. The PPV reported in this study (57%) was considerably lower than that reported in other studies.
Selected Patient Populations. A majority of the studies did not restrict the study sample to patients with specific diseases (other than HF). For example, most studies included the entire health plan membership or all Medicare beneficiaries without other restrictions. However, several studies included only patients with a certain condition (e.g., atrial fibrillation, hypertension, rheumatoid arthritis) and examined HF as a comorbidity or outcome. For example, Grijalva, et al.\textsuperscript{21} examined hospitalization for HF in patients with rheumatoid arthritis, and Curtis, et al.\textsuperscript{15} examined a small sample of patients (n=28) with rheumatoid arthritis or Crohn’s disease plus TNF-\(\alpha\) antagonist or immunosuppressive drug use. Brar and colleagues\textsuperscript{13} examined the incidence of peripartum cardiomyopathy in pregnant women hospitalized 6 months before or 9 months after delivery. Although the validation statistics for several of these select study samples were high (e.g., Grijalva, et al.;\textsuperscript{21} PPV = 100%), a number of the low validation statistics included in the report come from these studies of very specific patient populations. For instance, Brar and colleagues\textsuperscript{13} reported a PPV of 25% in the study of peripartum cardiomyopathy and Curtis and colleagues\textsuperscript{15} reported a PPV of 31% for the validation of HF in the small sample of patients with rheumatoid arthritis or Crohn’s disease. It seems that these more select patient populations may result in extreme values (both low and high) for validation statistics. In addition, and as described in more detail below (see section ‘Incident vs prevalent outcome validation’, the study by Brar and colleagues\textsuperscript{13} also focused on incident outcomes but did not systematically exclude prevalent cases at baseline, potentially contributing to low PPVs.

Age of Study Population. Most studies included only adult populations, with many studies including patients who were older (\(\geq 65\) years). Studies that included younger patients were generally those that included entire member populations of health plans, who were over a certain age (most commonly 18 years of age and older). Since the prevalence of HF increases with advancing age, in studies that included wide age ranges it is likely that a large proportion of the patients were \(\geq 65\) years. No information was provided on the proportion of validated cases of HF by age group. One study (Brar, 2007)\textsuperscript{13} indirectly excluded older patients because the study sample was restricted to pregnant women hospitalized with HF. In general, PPVs did not vary significantly according to whether the study populations included all ages or were restricted to older patients.

Patient Sex. One study (Lee, et al.)\textsuperscript{27} reported the validity of ICD-9 code 428.x according to patient’s sex, and found similar PPVs in males and females (94% and 95%, respectively, based upon Framingham criteria for CHF).

Time Period of Data Collection. This report includes publications between 1990 and 2009; a majority of the studies included report on study populations identified between 1990 and 2005. Several studies reported on earlier periods (e.g., Jollis, et al.\textsuperscript{24} reported on data from 1985-1990 and Klatsky, et al.\textsuperscript{26} reported on baseline data from 1978-1985 with follow-up through 2000). The reported validation statistics did not vary significantly in earlier study periods (i.e., prior to 2000) compared to later study periods (e.g., 2000 and later).

Incident vs Prevalent Outcome Validation. A majority of the studies validated both incident and prevalent cases of HF. Seven studies reported on incident outcomes.\textsuperscript{8,13,15,23,25,38,39} In general, the validation statistics for studies of incident cases of HF were adequate, ranging from 54-97%. With the exception of one study (Schellenbaum, 2006),\textsuperscript{39} all studies validating incident cases of HF used the Framingham criteria as the validation criteria. Schellenbaum and colleagues (2006)\textsuperscript{39} reported a significantly lower PPV for validation of incident HF in the Cardiovascular Health Study (PPV=54%). Events were confirmed by an events committee rather than by standardized clinical criteria (e.g.,
Framingham criteria,\textsuperscript{41} which may be a potential explanation for the lower percentage of cases validated. One study of a very select incident outcome (peripartum cardiomyopathy) reported a very low PPV (25% ; Brar, 2007).\textsuperscript{13} This sample was restricted to a specific patient population (i.e., pregnant women hospitalized with HF) and thus is less generalizable than the other samples studied in which the vast majority of patients were elderly. In addition, although this study was focused on identifying incident cases of HF, the investigators did not systematically identify prevalent cases of HF for exclusion at baseline, potentially contributing to the low PPV reported. Two studies examining incident episodes of HF systematically excluded patients with a prior diagnosis of HF (based on the ICD-9 codes used to identify the incident cases) in the 5 years before the years under study.\textsuperscript{23,25} Both studies reported high PPVs (96% and 97%), suggesting that the systematic exclusion of prevalent cases using the algorithm for identifying incident cases may be an important consideration in studies ascertaining newly diagnosed cases of HF. Only one study reported data to calculate validation statistics for both incident and prevalent outcomes (Ansari, 2003),\textsuperscript{8} thus allowing for a comparison of the two. This study reported a high PPV (97%) for all cases (prevalent and incident) of HF and a significantly lower, although adequate, PPV (78%) for incident cases of HF.

**Principal vs Secondary Diagnosis.** The outcome for a majority (n=27) of the studies included in this report was hospitalization for HF. Approximately half (n=14) of the studies reporting on hospitalization for HF specified that HF was the principal or most responsible discharge diagnosis in their algorithm for identification of cases. In general, the validation of HF in the studies that used the principal diagnosis was high, with all but one study (Austin, 2002)\textsuperscript{9} reporting PPV’s >90%. Austin and colleagues\textsuperscript{9} reported a considerably lower PPV of 65%, but, as described earlier, this study linked administrative claims with registry data rather than validating claims data with medical record review as was the case for the vast majority of other studies identified. The different validation procedure employed in this study may, in part, account for the difference in validated cases observed. Studies that identified cases of HF according to discharge diagnoses in any position had slightly lower validation statistics compared to the studies that used only the first or principal diagnosis, with PPVs ranging from 79% to 96%, with more than half <90%. Two studies separately validated both a primary discharge diagnosis of HF and a discharge diagnosis of HF in other positions.\textsuperscript{9,11} Birman-Deych, et al.\textsuperscript{11} compared an algorithm using the primary discharge diagnosis with another algorithm using the discharge diagnosis in any other position. The sensitivities and specificities for the primary discharge diagnosis of HF were 33% and 99%, respectively, compared to 83% and 86% for a diagnosis in any position. Using data from a registry of patients with an acute coronary syndrome as validation criteria, Austin, et al.\textsuperscript{9} reported a PPV of 65% for patients with a primary discharge diagnosis of HF and a PPV of 36% for patients with a primary or secondary discharge diagnosis.

**Hospitalization Diagnosis vs Outpatient Encounter.** The studies included in this report examined either hospitalizations or outpatient encounters to identify HF-related outcomes. A majority of the studies reported hospitalization for HF as the principal study outcome and these studies reported high validation statistics for their algorithms, with most being >95%. Eleven studies used outpatient encounters alone or in combination with hospitalizations to identify patients with HF. In general, these studies had lower PPV’s than studies using hospital discharge diagnoses only, with PPVs ranging from 63% to 97%, a majority of which were <90%. Several studies employed algorithms that included both inpatient and outpatient diagnoses, however, they did not directly compare algorithms using one versus the other. For instance, the algorithm reported by Go and colleagues (2006) included ≥1 hospitalization with a primary diagnosis of HF, ≥2 outpatient diagnoses of HF, or ≥3 emergency department visit
diagnoses of HF. This algorithm yielded a PPV of 97% for medical record review of physician assigned diagnosis of HF.

G. SUMMARY OF EXCLUDED POPULATIONS AND DIAGNOSES

As described in section F above, the majority of studies evaluated HF in adult patients. In addition, several studies included only patients with a certain medical condition (e.g., atrial fibrillation, hypertension or rheumatoid arthritis) that may have affected the PPVs observed. Few studies excluded patients with specific comorbid conditions. Exceptions included the study by Alqaisi, et al.,\(^7\) which excluded patients with a diagnosis of end stage renal disease or chronic obstructive pulmonary disease with steroid use. Another study by Ansari, et al.\(^8\) excluded patients with end stage renal disease on hemodialysis, dementia, HIV/AIDS, cirrhosis, or malignancy other than basal cell carcinoma. Curtis, et al.,\(^15\) excluded patients with a prior diagnosis of HIV, organ transplantation or malignancy.
### Table 4. Positive Predictive Values by Algorithm

<table>
<thead>
<tr>
<th>Citation</th>
<th>Study Population and Time Period</th>
<th>Description of Outcome Studied</th>
<th>Algorithm</th>
<th>Validation/Adjudication Procedure and Operational Definition</th>
<th>Validation Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahmed, et al. 6</td>
<td>secondary analysis of data from study by DeLong, et al., 1998; Medicare beneficiaries aged 65 or older identified using the Alabama Quality Assurance Foundation (AQAF) database, 1994</td>
<td>hospitalizations (prevalent and incident)</td>
<td>principal discharge diagnosis of heart failure identified with ICD-9-CM codes 428 and 402.91</td>
<td>Medical record review was conducted (N=1091). Outcome was confirmed based upon history of heart failure, symptoms (paroxysmal nocturnal dyspnea, orthopnea, dyspnea on exertion, dyspnea), signs (jugular venous distension, third heart sound, pulmonary rales, displaced point of maximum cardiac impulse), or radiographic evidence (pulmonary edema, pulmonary venous congestion or cardiomegaly) of heart failure, or treatment with both digoxin and diuretic.</td>
<td>two or more criteria: PPV=99% three or more criteria: PPV=86%</td>
</tr>
<tr>
<td>Alqaisi, et al. 7</td>
<td>members &gt; 18 years of age of a large HMO in southeast Michigan receiving care from a large, multispecialty medical group, 2004 to 2005</td>
<td>prevalent and incident</td>
<td>at least one encounter code for HF (excluding all emergency department encounters); various algorithms evaluated that included ICD9 codes: 428.xx, 398.91, 402.01, 402.11, or 402.91 plus laboratory data</td>
<td>Medical record review was conducted for patients with an HF ICD-9 code only. 400 patients sampled for chart review: derivation set, N=300; validation set, N=100. Outcome was confirmed if Framingham criteria for heart failure met: classified as having satisfied the Framingham definition for HF if met either two major PPVs: at least one HF encounter code: 65% met Framingham definition; for derivation data set: ≥ 2 HF encounters OR any hospital discharge diagnosis of HF OR BNP &gt; 200 pg/ml</td>
<td></td>
</tr>
</tbody>
</table>
### Congestive Heart Failure

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 2 HF encounters OR any hospital discharge diagnosis of HF: sensitivity=69%, specificity=81%</td>
<td>sensitivity=76%, specificity=75%</td>
<td></td>
</tr>
<tr>
<td>≥ 2 HF encounters OR BNP &gt; 200 pg/ml, sensitivity=70%, specificity=79%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 2 HF encounters OR any hospital discharge diagnosis of HF OR BNP &gt; 500 pg/ml: sensitivity=70%, specificity=78%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 2 HF encounters OR primary hospital discharge diagnosis of HF: sensitivity=60%, specificity=86%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 2 HF encounters OR BNP &gt; 100 pg/ml: sensitivity=76%, specificity=69%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 2 HF encounters: sensitivity=59%, specificity=86%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 2 HF encounters AND ≥ 1 BNP ≥ 50 pg/ml OR any hospital discharge diagnosis of HF OR BNP &gt; 200 pg/ml</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
HOI Evidence Reviews

Congestive Heart Failure

pg/ml:
sensitivity = 59%, specificity = 81%

> 2 HF encounters AND
> 1 BNP > 50 pg/ml OR
primary hospital discharge
diagnosis of HF
OR > 1 BNP ≥ 500 pg/ml:
sensitivity = 39%,
specificity = 91%

any hospital discharge
diagnosis of HF
OR BNP ≥ 500 pg/ml:
sensitivity = 41%,
specificity = 88%

any hospital discharge
diagnosis of HF:
sensitivity = 35%,
specificity = 92%

BNP > 100 pg/ml:
sensitivity = 49%,
specificity = 76%

BNP > 200 pg/ml:
sensitivity = 36%,
specificity = 88%

primary hospital discharge
diagnosis of HF
OR BNP > 500 pg/ml:
sensitivity = 24%,
specificity = 95%

BNP > 500 pg/ml:
sensitivity = 20%,
specificity = 95%

primary hospital discharge
diagnosis of HF:
<table>
<thead>
<tr>
<th>Study</th>
<th>Population Description</th>
<th>Methodology</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ansari, et al.⁸</td>
<td>members of northern California Kaiser Permanente, 1996 to 1997</td>
<td>Incident encounter form with ICD-9 codes 428.0, 425.0, 402.1, 402.11, 402.91, 404.01, 404.3, 404.11-.15 (excluding patients with a prior outpatient visit or primary or secondary diagnosis of a HF-related diagnosis on a prior hospital discharge and patients admitted within 24 h of their diagnosis)</td>
<td>Medical record review was conducted. A random sample of 529 patients selected for chart review plus additional 165 patients seen by cardiologist were reviewed. Outcome was confirmed if there was clinical evidence to support HF using Framingham criteria. PPV=97% for confirmation of HF PPV=78% for confirmation of 'incident' HF (subtracting missing charts/lack of follow-up and considering those with evidence of preceding HF to not meet definition of 'incident' case) PPV was calculated based upon data presented in article.</td>
</tr>
<tr>
<td>Austin, et al.⁹</td>
<td>patients ≥ 20 years of age included from Fastrak II acute coronary syndromes registry (cohort of patients admitted to coronary care units of 58 Ontario hospitals) and matched with Canadian Institute of Health Information (CIHI) hospital discharge data, prior to March 2000</td>
<td>hospitalizations (incident and prevalent) most responsible discharge diagnosis ICD-9 code 428; most responsible or secondary diagnosis ICD-9 code 428</td>
<td>Linkage to Fastrak II registry (data collected prospectively by nurse looking after patient) was performed. 14% of patients with discharge diagnosis could be linked to the Fastrak II CCU registry. Outcome was confirmed if HF diagnosis present in Fastrak II registry. most responsible diagnosis: specificity=96.8 %, sensitivity=58.5 %, PPV=65.1%; most responsible or secondary diagnosis: specificity=84.3 %, sensitivity=85.4 %, PPV=35.8%;</td>
</tr>
<tr>
<td>Baker, et al.¹⁰</td>
<td>patients &gt; 18 years of age seen 2 or more times in the general internal medicine clinic of</td>
<td>incident and prevalent diagnosis of heart failure on problem list or medical history but no encounter diagnoses and</td>
<td>Medical record review was conducted. Reviewed 28 charts for all patients who had a diagnosis of heart PPV=57% PPV was calculated based upon data presented</td>
</tr>
<tr>
<td>Study</td>
<td>Population Description</td>
<td>Diagnosis Criteria</td>
<td>Review Methodology</td>
</tr>
<tr>
<td>-------</td>
<td>------------------------</td>
<td>--------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>Birman-Deych, et al.\textsuperscript{11}</td>
<td>Medicare beneficiaries who were hospitalized with atrial fibrillation identified using the National Registry of Atrial Fibrillation II dataset, including anonymous patient records gathered by the Quality Improvement/Peer Review Organization for the National Stroke Project, 1998 to 1999</td>
<td>ICD-9-CM codes 428.x, 398.91, 402.01, 402.11, 402.91, 404.01, 404.11, 404.91, 404.03, 404.93, 404.13, 404.93</td>
<td>Medical record review was conducted. Outcome was confirmed if there was documentation of a history of heart failure and/or current heart failure.</td>
</tr>
<tr>
<td>Borzecki, et al.\textsuperscript{12}</td>
<td>Veterans Affairs patients with at least 1 hypertension diagnosis (ICD-9-CM codes: 398.91, 402.01, 402.11, 402.91, 404.01, 404.03)</td>
<td>Inpatient or outpatient ICD-9-CM codes: 398.91, 402.01, 402.11, 402.91, 404.01, 404.03</td>
<td>Medical record review was conducted (981 patients with a hypertension)</td>
</tr>
</tbody>
</table>
CM code 401, 402, or 405) and additional sample without a hypertension diagnosis identified using the Out-Patient Clinic (OPC) and Patient Treatment (PTF) file, Department of Veterans Affairs (VA) databases, 1998 to 1999

<table>
<thead>
<tr>
<th>Study</th>
<th>Population Description</th>
<th>Methods</th>
<th>Outcome</th>
<th>PPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brar, et al.13</td>
<td>Female members of Kaiser Permanente Southern California hospitalized with HF 6 months before or 9 months after delivery, 1996 to 2005</td>
<td>Hospitalizations/incident peripartum cardiomyopathy with HF identified through ICD-9-CM codes 428.0, 428.1, 428.4, 428.9, 425.4, 425.9</td>
<td>Medical record review was conducted (N=240). Peripartum cardiomyopathy was confirmed if all following criteria met: ejection fraction &lt; 0.50, met Framingham criteria for HF, new symptoms of HF or initial diagnosis of left ventricular dysfunction occurred in the month before or in the 5 months after delivery, and no other cause of HF could be identified</td>
<td>25%</td>
</tr>
<tr>
<td>Brophy, et al.14</td>
<td>Patients diagnosed with atrial fibrillation identified using the Veterans Affairs Boston Healthcare System database, 1998 to 2001</td>
<td>Inpatient or outpatient ICD-9-CM code 428.x</td>
<td>Medical record review was conducted. Criteria for confirmation of cases was unspecified.</td>
<td>98%</td>
</tr>
<tr>
<td>Curtis, et al.15</td>
<td>Members of a large geographically diverse US health care organization &gt; 50 years of age</td>
<td>Incident</td>
<td>Medical record review was conducted (N=29). Confirmed cases satisfied at least 1 major and 2 minor</td>
<td>31%</td>
</tr>
<tr>
<td>Study</td>
<td>Patients</td>
<td>Diagnosis</td>
<td>Validation</td>
<td>PPV</td>
</tr>
<tr>
<td>-------</td>
<td>----------</td>
<td>-----------</td>
<td>------------</td>
<td>-----</td>
</tr>
<tr>
<td>DeLong, et al.</td>
<td>Medicare beneficiaries aged 65 or older identified using the Alabama Quality Assurance Foundation (AQAF) database, 1994 (baseline) and 1995 to 1997 (follow-up)</td>
<td>hospitalizations (prevalent and incident)</td>
<td>Medical record review was conducted (N=1720). Outcome was confirmed based upon history (dyspnea on exertion, paroxysmal nocturnal dyspnea, orthopnea, or edema) and physical examination (rales or edema) and either an LVEF &lt; 40% or a chest radiograph with pulmonary edema or cardiomegaly</td>
<td>PPV=93%</td>
</tr>
<tr>
<td>Ezekowitz, et al.</td>
<td>patients older than 18 years of age, Alberta, Canada, 2002 to 2003 (from Richter, et al., incident and prevalent</td>
<td>emergency department most responsible diagnosis ICD-10 IS0.X code</td>
<td>Medical record review was conducted (N=483). Outcome was confirmed based</td>
<td>PPV=30%</td>
</tr>
<tr>
<td>2009)</td>
<td>Kaiser Permanente of Northern California members ≥ 20 years of age, 1996 to 2004</td>
<td>≥ 1 hospitalization with a principal diagnosis of HF (ICD-9 codes: 398.91, 402.01, 402.11, 402.91, 428.0, 428.1, 428.9); 2 hospitalizations with a secondary diagnosis of HF with the principal diagnosis related to the disease (e.g. CHD); ≥ 3 hospitalizations with secondary diagnosis of HF; ≥ 2 outpatient diagnoses; ≥ 3 emergency department visit diagnoses; ≥ 2 more inpatient secondary diagnoses plus 1 outpatient diagnosis</td>
<td>Medical record review was conducted (N=9533). Outcome was confirmed if a physician-assigned heart failure diagnosis was documented.</td>
<td>PPV=97%</td>
</tr>
</tbody>
</table>

| 2009) | patient admitted to special care units at 7 hospitals in Nueces County, Texas with diagnoses possibly indicative of CHD and those who underwent bypass surgery or revascularization, aged 25 through 74 year, 1998 to 1994 | discharge diagnosis ICD-9 codes: 398.91, 402.x1, 404.x, 415.0, 416.9, 425.4, 428.x, 429.4, 514, 518.4, 786.0; 3 algorithms assessed: 1) presence of ICD-9 428; 2) presence of either ICD-9 code 428 or 402; presence of any of ICD codes listed above | Medical record review was conducted (N=5083). Outcome was confirmed if documentation in a progress note or in the discharge summary that the patient experienced an episode of acute CHF or notation of pulmonary edema in a report of a chest radiograph. | 1) presence of ICD-9 428: Sensitivity=62.8%, Specificity=95.4%, PPV=83.5%, NPV=87.4% |
| | | | | 2) presence of either ICD-9 code 428 or 402: Sensitivity=66.2%, Specificity=93.3%, PPV=78.5%, NPV=88.2%; |
| | | | | 3) presence of any of ICD-9 codes listed:
<table>
<thead>
<tr>
<th>Study</th>
<th>Population Description</th>
<th>Hospitalizations (new onset or exacerbation of CHF)</th>
<th>Principal Discharge Diagnosis (ICD9 CM code 428.X)</th>
<th>Medical Record Review Details</th>
<th>Outcome Confirmation Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grijalva, et al. 21</td>
<td>TennCare enrollees ≥ 18 years diagnosed with rheumatoid arthritis, 1995 to 2004</td>
<td>hospitalizations</td>
<td>principal discharge diagnosis of ICD9 CM code 428.X</td>
<td>Medical record review was conducted (N=38). Outcome was confirmed if CHF was considered the main reason for hospitalization and at the end of the hospitalization, the treating physicians considered it to be the main cause of the hospitalization.</td>
<td>PPV=100%</td>
</tr>
<tr>
<td>Havranek, et al. 22</td>
<td>Medicare patients throughout the U.S. (National Heart Failure project), 1988 to 1999</td>
<td>hospitalizations</td>
<td>principal discharge diagnosis ICD-9 codes: 428.x, 402.01, 402.11, 402.91, 404.01, 404.11, 404.91, 428.x</td>
<td>Medical record review was conducted (N=100). Outcome was confirmed based upon cardiologist review and judgment.</td>
<td>PPV=99%</td>
</tr>
<tr>
<td>Iribarren, et al. 23</td>
<td>Kaiser Permanente Northern California members ≥ 19 years of age with diabetes who were responders to a survey and who had no previous hospitalization with a primary or secondary diagnosis of HF during the 5 years before, 1995 to 1997</td>
<td>hospitalizations</td>
<td>primary discharge diagnosis of ICD-9 codes: 428.x, 402.01, 402.11, 402.91</td>
<td>Medical record review was conducted for a random sample of 200 patients. Outcome was confirmed based upon Framingham criteria.</td>
<td>PPV=97%</td>
</tr>
<tr>
<td>Jollis, et al. 24</td>
<td>discharges containing a procedure code for coronary arteriography identified using</td>
<td>hospitalizations</td>
<td>discharges with an ICD-9-CM code of 428.0, 428.1, 428.9, 398.91, 402.01, 402.11</td>
<td>Clinic database was compared to coding by medical record technicians (N=12937). Outcome was confirmed based</td>
<td>sensitivity= 36%, specificity= 96%</td>
</tr>
<tr>
<td>Reference</td>
<td>Study Design</td>
<td>Diagnosis Identification</td>
<td>Methodology</td>
<td>PPV (%)</td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>Jong, et al.²⁵</td>
<td>Patients ≥ 20 years of age, hospitalized in Ontario (14 acute care hospitals; Canadian Institute for Health Information), 1997 to 1999</td>
<td>Hospitalizations (incident)</td>
<td>Medical record review was conducted (N=1346). Outcome was confirmed if 2 major or 1 major and 2 minor Framingham criteria were concurrently present, or if the Carlson heart failure score exceeded 4 points.</td>
<td>96% (Framingham criteria)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Primary diagnosis of ICD-9 code 428; excluded those transferred from another acute care facility, cases where HF was coded as a hospital complication, and cases in which it was not the first admission for HF and patients who had a diagnosis of HF coded during any hospital admission in the 5 years before this study</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Klatsky, et al.²⁶</td>
<td>Kaiser Permanente members, San Francisco and Oakland, 1978 to 1985 (baseline) through 2000</td>
<td>Hospitalizations (incident and prevalent)</td>
<td>Medical record review was conducted (N=1907). Outcome was confirmed based upon Framingham criteria.</td>
<td>95%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Primary discharge diagnosis code 428 (and no separate primary discharge diagnosis of CAD-codes 411 to 414)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lee, et al.²⁷</td>
<td>Patients &lt; 105 years of age admitted to 14 hospitals in Ontario, identified using the Canadian Institute for Health Information (CIHI) discharge abstract database, 1997 to 1999</td>
<td>Hospitalizations (incident and prevalent)</td>
<td>Medical record review was conducted (836 women and 805 men). Outcome was confirmed based upon Framingham criteria and Carlson criteria.</td>
<td>87.8% in men (Carlson criteria)</td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Population</td>
<td>Methodology</td>
<td>Diagnosis</td>
<td>Medical record review</td>
<td>PPV</td>
</tr>
<tr>
<td>-------</td>
<td>------------</td>
<td>-------------</td>
<td>-----------</td>
<td>-----------------------</td>
<td>-----</td>
</tr>
<tr>
<td>Lee, et al. 28</td>
<td>Kaiser Permanente of Northern California members ≥ 18 years of age, 1999 to 2000</td>
<td>Hospitalizations (incident and prevalent)</td>
<td>ICD-9 codes: 402.01, 402.11, 402.91, 425.0 to 425.5, 425.7, 428.0, 428.1, 428.9</td>
<td>Medical record review was conducted (N=1700). Outcome was confirmed based upon Framingham clinical criteria.</td>
<td>PPV=93.6%</td>
</tr>
<tr>
<td>Lentine, et al. 29</td>
<td>Kidney transplant patients at Washington University ages ≥18 years with Medicare as primary insurer, 1991 to 2002</td>
<td>Incident or prevalent</td>
<td>ICD-9-CM codes: 398.91, 422, 425, 428, 402.x1, 404.x1, 404.x3, V42.1; identified with Medicare Part A (institutional) claims and/or Medicare Part B (physician/suppliers) claims</td>
<td>Transplant center’s clinical database was used to confirm HF, including physician-reported diagnosis plus objective evidence of cardiac dysfunction: echocardiography or other forms of ventriculography, chest radiograph, and/or B-natriuretic peptide.</td>
<td>Claims within 30 days from event date recorded in the database: Medicare Part A sensitivity = 75.0% (95% CI 63.7 - 86.3%); Part B sensitivity = 85% (95% CI 75.7% - 94.3%); Part A or B sensitivity = 92.5% (95% CI 85.6% - 99.4%); 1 Part A claim or 2 Part B claims submitted at least 1 day but no more than 365 days apart: sensitivity = 92.5%</td>
</tr>
<tr>
<td>McCullough, et al. 30</td>
<td>Henry Ford Health System members, 1989 to 1999</td>
<td>Incident or prevalent</td>
<td>≥ 2 outpatient or one hospitalization from ICD-9-CM codes: 428.x, 398.91, 402.01, 402.11, 402.91, 404.00, 404.01, 404.03, 404.10, 404.11, 404.13, 404.90, 404.91, 404.93. Hospitalizations required DRG 127 OR one of the ICD-9-CM codes in the</td>
<td>Medical record review was conducted (1% sample; N=271). Outcome was confirmed based upon Framingham criteria, NHANES definition of CHF, and confirmation by an internist and cardiologist by chart notes</td>
<td>Framingham criteria: PPV=63.5%; NHANES definition (score ≥3): PPV=55.7%; physician assessment: PPV=82.9%</td>
</tr>
<tr>
<td>Study</td>
<td>Population</td>
<td>Classification</td>
<td>Diagnosis/ICD-9 Codes</td>
<td>Medical Record Review</td>
<td>Outcome Confirmation Method</td>
</tr>
<tr>
<td>-------</td>
<td>------------</td>
<td>----------------</td>
<td>----------------------</td>
<td>----------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Owan, et al. 31</td>
<td>Patients admitted to Mayo Clinic hospitals, 1987 to 2001</td>
<td>Hospitalizations (incident and prevalent)</td>
<td>Inpatient ICD-9-CM code 428 plus DRG code 127</td>
<td>Medical record review was conducted (N=135).</td>
<td>Outcome was confirmed based upon modified Framingham criteria or the clinical criterion (diagnosis of HF recorded on the chart by the attending physician).</td>
</tr>
<tr>
<td>Park, et al. 32</td>
<td>Medicare beneficiaries ≥ 65 years, 1983 to 1984</td>
<td>Hospitalizations (incident and prevalent)</td>
<td>Principal diagnosis ICD-9 codes 398.91, 402.11, 402.91, 428.0, 428.1, 428.9, 785.51</td>
<td>Medical record review was conducted (N=1600).</td>
<td>Outcome was confirmed based upon review and determination by physician principal investigator that the principal diagnosis was accurately coded.</td>
</tr>
<tr>
<td>Philbin, et al. 33</td>
<td>New York state hospital discharges (Statewide Planning and Research Cooperative System (SPARCS) database—New York state), 1995</td>
<td>Hospitalizations (incident and prevalent)</td>
<td>Principal diagnosis ICD-9-CM codes 428.0, 402.91, 404.93, 428.1, 428.9, 398.91, 404.91, 404.13, 402.01, 404.03, 404.11, 404.01, 428.9</td>
<td>Medical record review was conducted (3% sample).</td>
<td>Outcome was confirmed based upon documentation of typical symptoms, physical findings, laboratory results, and response to appropriate therapy.</td>
</tr>
<tr>
<td>Philbin, et al. 34</td>
<td>Patients from 10 acute care hospitals collaborating in a study of quality of care in CHF, 1995</td>
<td>Hospitalizations (incident and prevalent)</td>
<td>DRG codes 127 and DRG code 124 with principal diagnosis was one of the ICD-9 codes required for DRG 127</td>
<td>Medical record review was conducted.</td>
<td>Outcome was confirmed based upon presence of appropriate medical history, physical findings, lab results and response to appropriate therapy.</td>
</tr>
<tr>
<td>Study</td>
<td>Populations</td>
<td>Methods</td>
<td>Results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>-------------</td>
<td>---------</td>
<td>---------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quan, et al.</td>
<td>Hospitalizations identified using Calgary Regional Health Authority data, 1996 to 1997</td>
<td>Hospitalizations assigned comorbidity using algorithm developed by Deyo, et al. 1992 (Deyo, et al., assigns ICD-9-CM codes 428, 428.9 to identify HF)</td>
<td>Medical record review was conducted (N=1200). Outcome was confirmed based upon definitions described by Charlson, et al., 1987</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rathore, et al.</td>
<td>Medicare beneficiaries from CMS National Heart Failure Project, 1998 to 1999, 2000 to 2001</td>
<td>Hospitalizations assigned ICD-9 codes 402.01, 402.11, 402.91, 404.01, 404.91, 428</td>
<td>Medical record review was conducted (N=66178). Outcome was confirmed based upon clinical evidence.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rodeheffer, et al.</td>
<td>Olmstead County, MN residents ages 0 to 74 years (Rochester Epidemiology Project), 1981 to 1982</td>
<td>Incident and prevalent</td>
<td>ICD-8 code 427</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roger, et al.</td>
<td>Olmstead County, MN residents (Rochester Epidemiology Project), 1997 to 2000</td>
<td>Incident</td>
<td>ICD-9-CM 428: PPV=82% Other codes used in isolation without a code 428 met Framingham criteria for 14% to 30% of patients.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schellenbaum, et al.</td>
<td>Cardiovascular health Study: Medicare eligible residents (≥ 65 years) in Sacramento County, CA; Washington County, MD; Forsyth County, NC; Allegheny County, PA, 1989,</td>
<td>Hospitalizations discharge diagnosis ICD-9 428, 997.1, 425, 402.01, 402.11, 402.91, 398.91</td>
<td>Medical record review was conducted (N=1209) and outcome was confirmed based upon decision by an Events Committee consisting of 5 physicians after review of documentation on medical history.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Sensitivity=77.3%, specificity=98.7%; PPV=87.6%; NPV=97.3%
- PPV=92.4%
- PPV=69.6%
- PPV=54%
**I. CLINICIAN OR TOPIC EXPERT CONSULTATION**

Use of ICD-9 code 428.x appears appropriate based on this review, with the caveat that it will have a high PPV and specificity, but may have a low sensitivity.

The distinction between incident and prevalent cases is a fundamental issue that will need to be addressed. Specifically, it will be important to specify at the outset of a study which type of case is specifically of interest; a study examining the association between a drug exposure and the new occurrence of HF will require an algorithm that identifies incident cases with a high PPV. However, prevalent cases would be of interest when examining the prescribing of medications that are contraindicated in patients with HF, or in identifying a cohort of patients with an existing diagnosis who are followed prospectively for exacerbations leading to hospitalization. The mixing of incident with prevalent cases will impact on validation statistics.

Further study is warranted to determine how the use of procedure codes as part of the algorithm will affect the PPV. For example, how does the presence of a code indicating the performance of an echocardiogram or a nuclear perfusion imaging study impact the PPV if included in the algorithm? This may be particularly helpful for identifying HF patients diagnosed in the ambulatory setting, as the vast majority of patients with HF will have undergone at least one echocardiogram, but many patients may not have had a hospitalization for HF. While few algorithms that employ outpatient encounters exist, most care of HF patients occurs in the outpatient setting. Comparison of algorithms employing inpatient

| So, et al. | 1990, 1992, 1993 | hospitalizations (incident and prevalent) | inpatient ICD-9-CM codes: 428.x; ICD-10 codes: I09.9, I11.0, I13.0, I13.2, I25.5, I42.0, I42.5-I42.9, I43.x, I50.x, P29.0 | Medical record review was conducted (N=193) and outcome was confirmed based upon evidence of HF in chart. | ICD-9-CM: sensitivity = 81.8% (95% CI 69.1 - 92.0); specificity = 96.4% (91.8 - 98.8); PPV = 90.0% (78.2 - 96.7); NPV = 93.0% (87.5 - 96.6); ICD-10 codes: sensitivity = 80.0% (67.0 - 90.0); specificity = 97.8% (93.8 - 99.6); PPV = 93.6% (82.5 - 98.7); NPV = 92.5% (86.9 - 96.2) |

---

**Table:**

| So, et al. | 1990, 1992, 1993 | hospitalizations (incident and prevalent) | inpatient ICD-9-CM codes: 428.x; ICD-10 codes: I09.9, I11.0, I13.0, I13.2, I25.5, I42.0, I42.5-I42.9, I43.x, I50.x, P29.0 | Medical record review was conducted (N=193) and outcome was confirmed based upon evidence of HF in chart. | ICD-9-CM: sensitivity = 81.8% (95% CI 69.1 - 92.0); specificity = 96.4% (91.8 - 98.8); PPV = 90.0% (78.2 - 96.7); NPV = 93.0% (87.5 - 96.6); ICD-10 codes: sensitivity = 80.0% (67.0 - 90.0); specificity = 97.8% (93.8 - 99.6); PPV = 93.6% (82.5 - 98.7); NPV = 92.5% (86.9 - 96.2) |
encounters, outpatient encounters, or both are needed. The impact of incorporating both inpatient and outpatient encounters in an algorithm deserves further study.

The Framingham criteria remain the ‘gold standard’ for validation of HF. However, it is of interest how the inclusion of contemporary and widely employed diagnostic tests including BNP (brain natriuretic peptide) levels into HF diagnostic criteria might impact sensitivity and specificity.

It is very important to be able to differentiate HF patients with preserved systolic function from those with systolic dysfunction, but it is unlikely that an algorithm based on diagnostic codes would be able to help with this differentiation.

VI. SUMMARY AND CONCLUSIONS

A. RECOMMENDATIONS FOR ALGORITHMS

Studies that included a primary hospital discharge diagnosis of ICD-9 code 428.X had the highest PPV and specificity. PPVs for this algorithm ranged from 84% - 100%. This algorithm, however, may compromise sensitivity since many HF patients are managed on an outpatient basis. Including outpatient codes in this algorithm would increase the sensitivity.

B. SUGGESTIONS FOR FUTURE RESEARCH BASED ON EVIDENCE GAPS

Gaps in the current literature include specific comparisons of algorithms for hospitalized versus outpatient study populations with possible HF. Comparison of the validation of inpatient and outpatient algorithms against the Framingham Heart Study criteria for CHF would be most useful in order to compare the findings from other studies, as would the validation of incident versus prior events. Algorithms also have not been validated in different age strata, particularly in elderly and very elderly patient populations with additional comorbidities, who comprise the majority of patients presenting with HF. In addition, very few validation studies have been conducted on ICD-10 codes or in patients of different race/ethnicities in whom the criteria published to date may have varying sensitivities and specificities. In addition, current coding systems do not allow for algorithms that distinguish systolic and diastolic HF or that detail a patient’s HF stage.
VII. REFERENCES


VIII. APPENDICES

A. APPENDIX A: ABSTRACTS OF STUDIES INCLUDED IN EVIDENCE TABLE


**BACKGROUND:** Atrial fibrillation is common in older adults with heart failure. It is known to adversely affect outcomes. **AIM:** To examine the associations of atrial fibrillation with 4-year mortality and 30-day readmission in older adults hospitalized with heart failure. **METHODS:** Patients were Medicare beneficiaries 65 years of age and older discharged with a primary diagnosis of heart failure. Baseline data were obtained by retrospective chart reviews and data on mortality and readmission were obtained from Medicare administrative files. Presence of atrial fibrillation was confirmed using electrocardiogram during hospital admission. Using Cox proportional hazards models we estimated bivariate and multivariable (adjusted for various patient and care covariates) hazards ratios (HR) and 95% confidence intervals (CI) for 4-year mortality and 30-day readmission of patients with atrial fibrillation compared with those without. **RESULTS:** Patients (n=944) had a mean age (+/-S.D.) of 79 (+/-7) years, 61% were women, 18% African-Americans, 25% had atrial fibrillation by admission electrocardiogram, 64% died within 4 years, and 8% were readmitted. Patients with atrial fibrillation had a 52% increased risk of 4-year mortality (adjusted HR=1.52; 95%CI=1.11-2.07). Atrial fibrillation was also associated with higher risk of readmission (unadjusted HR=1.64; 95%CI=1.01-2.68). However, the association lost its statistical significance after adjustment for various patient and care variables (adjusted HR=2.09; 95%CI=0.94-4.65). **CONCLUSION:** Presence of atrial fibrillation was associated with significant increased risk of long-term mortality in older adults hospitalized with heart failure and was associated with a non-significant higher risk of hospital readmission.


**BACKGROUND:** Accurately identifying heart failure (HF) patients from administrative claims data is useful for both research and quality of care efforts. Yet, there are few comparisons of the various claims data criteria (also known as claims signatures) for identifying HF patients. We compared various HF claim signatures to assess their relative accuracy. **METHODS:** In this retrospective study, we identified 4174 patients who received care from a large health system in southeast Michigan and who had >or=1 HF encounter between January 1, 2004 and December 31, 2005. Four hundred patients were chosen at random and a detailed chart review was performed to assess which met the Framingham HF criteria. The sample was divided into 300 subjects for derivation and 100 subjects for validation. Sensitivity, specificity, and area under the curve (AUC) were determined for the various claim signatures. The criteria with the highest AUC were retested in the validation set. **RESULTS:** Of the 400 patients sampled, 65% met Framingham HF criteria, and 56% had at least one B-type Natriuretic Peptide (BNP) measurement. There was substantial variation between claims signatures in terms of sensitivity (range 15%-77%) and specificity (range 69%-100%). The best performing criteria in the derivation set were if patients met any one of the following: >or=2 HF encounters, any hospital discharge diagnosis of HF, or a BNP >or=200 pg/ml. These criteria showed a sensitivity of 76%, specificity of 75%, and AUC of 0.754 for meeting the Framingham HF criteria. This claims signature performed similarly in the validation set. **CONCLUSION:** Claim signatures for HF vary greatly in their relative sensitivity and specificity. These findings may facilitate efforts to identify HF patients for research and quality improvement efforts.

OBJECTIVES: This study examined the outcomes of new onset heart failure (HF) outpatients managed by cardiologists and primary care (PC) physicians. BACKGROUND: Several studies have sought differences in outcomes between patients with HF managed by cardiologists and PC physicians, but most focused on inpatients, who often represent later stages of HF, whereas many treatments have their impact by delaying disease progression. METHODS: This was a retrospective cohort study of incident HF identified between 1996 and 1997 in a staff model health maintenance organization. Cardiology care was defined as >/=2 visits or >/=25% of total medical outpatient visits to cardiology. Records from a cohort of 403 patients with new onset outpatient HF were reviewed. The main outcome measure was a combination of death and/or cardiovascular hospitalization at 24 months. RESULTS: Cardiologists' patients (n = 198) were younger (66 vs 71 years, p = 0.001), were more likely men (54% vs 46%, p = 0.01), had coronary artery disease (64% vs 42%, p = 0.001), and had a low (<45%) ejection fraction (EF) (66% vs 44%, p < 0.001) compared with PC physicians' patients. More cardiologists' patients received an EF assessment (94% vs 74%, p < 0.001), angiotensin-converting enzyme inhibitors (83% vs 68%, p < 0.001), and beta-blockers (38% vs 22%, p < 0.001). In multivariate proportional hazards modeling that included variables that differed between providers and univariate predictors of outcomes, cardiology care was an independent predictor of a lower risk for the combined outcome (hazard ratio 0.62, confidence interval 0.42 to 0.93, p = 0.02). CONCLUSIONS: Cardiology care at this early stage of HF is associated with improved guideline adherence and a reduced risk of the composite outcome of death plus cardiovascular hospitalization.


BACKGROUND: Cardiac health services researchers frequently use cohorts derived from administrative hospital discharge abstract data to study the outcomes and treatment of coronary artery disease. However, relatively limited data exist on the accuracy of the coding of cardiac diagnoses in discharge abstract data. The goal of this study was to examine the accuracy of the coding of acute myocardial infarction and other cardiac diagnoses in the Canadian Institute of Health Information hospital discharge abstracts. METHODS: Patients admitted to 58 cardiac care units (CCUs) in Ontario that participated in the Fastrak II Acute Coronary Syndromes registry were linked to CIHI hospital discharge abstracts. The most responsible diagnosis at hospital discharge in the administrative data was compared with the CCU discharge diagnosis in the clinical registry. RESULTS: A total of 58,816 CCU patients were linked to hospital discharge abstract data. The specificity, sensitivity, and positive predictive value of a most responsible diagnosis of acute myocardial infarction were 92.8%, 88.8%, and 88.5%, respectively. The specificity of CIHI diagnosis codes for arrhythmia, congestive heart failure, unstable angina, and chest pain not yet diagnosed were all at least 93.9%. However, the sensitivity of these CIHI diagnosis codes was no greater than 60.7%. Furthermore, the positive predictive values were no larger than 80.8%. CONCLUSION: Myocardial infarction is generally accurately coded in Ontario hospital discharge abstract data. However, other cardiac diagnoses are less reliably coded in discharge abstract data.

BACKGROUND: Electronic health records (EHRs) may be used to assess quality of care. OBJECTIVE: To evaluate the accuracy of automated review of EHR data to measure quality of care for outpatients with heart failure. DESIGN: Observational study of quality of care for heart failure comparing automated review of EHR data with automated review followed by manual review of electronic notes for patients with apparent quality deficits (hybrid review). SETTING: An academic general internal medicine clinic with several years’ experience using a commercial EHR. PATIENTS: 517 adults with a qualifying International Classification of Diseases, Ninth Revision, diagnosis of heart failure in their EHR data and 2 or more clinic visits over the past 18 months. MEASUREMENTS: Left ventricular ejection fraction (LVEF), prescription of a beta-blocker and an angiotensin-converting enzyme (ACE) inhibitor or angiotensin-receptor blocker (ARB) for patients with left ventricular systolic dysfunction (LVEF <0.40) and prescription of warfarin for patients with comorbid atrial fibrillation. RESULTS: Performance based on automated review of EHR data was similar to that based on hybrid review for assessing LVEF measurement (94.6% vs 97.3%), prescription of beta-blockers (90.9% vs 92.8%), and prescription of ACE inhibitors or ARBs (93.9% vs 98.7%). However, performance based on automated review was lower than that based on hybrid review for prescription of warfarin for atrial fibrillation (70.4% vs 93.6%), primarily because automated review did not detect documentation of accepted reasons for not prescribing warfarin. LIMITATIONS: The findings may not be applicable to other practices and other EHRs. The authors used EHR data to identify eligible patients, so the study may have excluded some patients with heart failure. Patient charts were manually reviewed only if a provider appeared to fail a quality measure on automated review and did not determine the sensitivity and specificity of automated review according to standard definitions. CONCLUSIONS: Automated review of EHR data to measure the quality of care of outpatients with heart failure missed many exclusion criteria for medications documented only in providers' notes. As a result, it sometimes underestimated performance on medication based quality measures.


OBJECTIVES: We sought to determine which ICD-9-CM codes in Medicare Part A data identify cardiovascular and stroke risk factors. DESIGN AND PARTICIPANTS: This was a cross-sectional study comparing ICD-9-CM data to structured medical record review from 23,657 Medicare beneficiaries aged 20 to 105 years who had atrial fibrillation. MEASUREMENTS: Quality improvement organizations used standardized abstraction instruments to determine the presence of 9 cardiovascular and stroke risk factors. Using the chart abstractions as the gold standard, we assessed the accuracy of ICD-9-CM codes to identify these risk factors. MAIN RESULTS: ICD-9-CM codes for all risk factors had high specificity (>0.95) and low sensitivity (or =0.98) but moderate positive predictive values (range, 0.54-0.77) in this population. CONCLUSIONS: Using ICD-9-CM codes alone, heart failure, coronary artery disease, diabetes, hypertension, and stroke can be ruled in but not necessarily ruled out. Where feasible, review of additional data (e.g., physician notes or imaging studies) should be used to confirm the diagnosis of valvular disease, arterial peripheral embolus, intracranial hemorrhage, and deep venous thrombosis.


The objective was to determine the best strategy for identifying outpatients with hypertension-related diagnoses using Veterans Affairs (VA) administrative databases. We reviewed 1176 outpatient charts from 10 VA sites in 1999, taking the presence of 11 diagnoses relevant to
hypertension management as the "gold standard" for identifying the comorbidity. We calculated agreement, sensitivity, and specificity for the chart versus several administrative data-based algorithms. Using 1999 data and requiring 1 administrative diagnosis, observed agreement ranged from 0.98 (atrial fibrillation) to 0.85 (hyperlipidemia), and kappas were generally high. Sensitivity varied from 38% (tobacco use) to 97% (diabetes); specificity exceeded 91% for 10 of 11 diagnoses. Requiring 2 years of data and 2 diagnoses improved most measures, with minimal sensitivity decrease. Agreement between the database and charts was good. Administrative data varied in its ability to identify all patients with a given diagnosis but identified accurately those without. The best strategy for case-finding required 2 diagnoses in a 2-year period.


There are no large population-based studies on the incidence and prognosis of peripartum cardiomyopathy (PC). Between 1996 and 2005, there were 241,497 deliveries within the Southern California Kaiser healthcare system. Among these, we identified 60 cases of PC by searching for an International Classification of Diseases, Ninth Edition diagnosis of heart failure (HF) and detailed chart review. PC was confirmed if all of the following criteria were satisfied: (1) left ventricular ejection fraction <0.50, (2) met the Framingham criteria for HF, (3) new symptoms of HF or initial echocardiographic diagnosis of left ventricular dysfunction occurred in the month before or in the 5 months after delivery, and (4) no alternative cause of HF could be identified. The overall incidence of PC was 1 in 4,025 deliveries. The incidence in whites, African-Americans, Hispanics, and Asians was 1 of 4,075, 1 of 1,421, 1 of 9,861, and 1 of 2,675 deliveries, respectively. The incidence of PC was greatest in African-Americans, which was 2.9-fold higher compared with whites (p = 0.03) and 7-fold that of Hispanics (p <0.001). With a mean follow-up of 4.7 years, the freedom from all-cause death was 96.7% by the Kaplan-Meier method. In conclusion, this large population-based study highlights important racial differences in the incidence of PC. We observed the lowest incidence of PC in Hispanics and the highest in African-Americans. Our findings also suggest that the current mortality associated with PC may be less than reported in older series, perhaps because of the high utilization of modern HF therapy.


OBJECTIVES: To determine the influence of advanced age on anticoagulant use in subjects with atrial fibrillation and to explore the extent to which risk factors for stroke and contraindications to anticoagulant therapy predict subsequent use. DESIGN: Retrospective cohort study. SETTING: The Veterans Affairs Boston Healthcare System. PARTICIPANTS: A total of 2,217 subjects with nonvalvular atrial fibrillation. MEASUREMENTS: Administrative databases were used to identify subject's age, anticoagulant use, and the presence of a diagnosis of atrial fibrillation, cerebrovascular accident, hypertension, diabetes mellitus, congestive heart failure, or gastrointestinal or cerebral hemorrhage. RESULTS: Unadjusted analysis showed no difference in warfarin use between those aged 75 and older and younger subjects regardless of the presence (33.9% vs 35.7%, P=.37) or absence (33.4% vs 34.7%, P=.58) of contraindications to anticoagulant therapy. Multivariate modeling demonstrated a 14% reduction (95% confidence interval (CI)=4-22%) in anticoagulant use with each advancing decade of life. Intracranial hemorrhage was a significant deterrent (odds ratio (OR)=0.27 95% CI=0.06-0.85). History of hypertension (OR=2.90, 95% CI=2.15-3.89), congestive heart failure (OR=1.70, 95% CI=1.41-2.04), and cerebrovascular accident (OR=1.54, 95% CI=1.25-1.89) were significant independent predictors for anticoagulant use. CONCLUSION:
Despite consensus guidelines to treat all atrial fibrillation patients aged 75 and older with anticoagulants, advancing age was found to be a deterrent to warfarin use. Better estimates of the risk:benefit ratio for oral anticoagulant therapy in older patients with atrial fibrillation are needed to optimize decision-making.


**OBJECTIVES:** New onset heart failure (HF) has been associated with the use of TNF-alpha antagonists etanercept and infliximab based upon spontaneous adverse event reports. HF clinical trials of these agents were stopped early due to futility or worsening of existing HF. A potential association between etanercept and infliximab and new onset HF has been studied minimally at a population level. **METHODS:** Using administrative claims from a large U.S. health care organization, we identified rheumatoid arthritis (RA) and Crohn’s disease (CD) patients receiving infliximab or etanercept (exposed), and comparator cohorts of RA and CD patients receiving non-biologic immunosuppressives (unexposed). We studied adults < 50 years to reduce potential confounding related to common age-related comorbidities. Based on abstracted medical records of suspected HF cases, a physician panel adjudicated cases as definite, possible or no HF. **RESULTS:** Among 4018 RA and CD patients with mean duration follow-up of 18 months, 9 of 33 suspected HF cases (identified using claims data) were adjudicated as definite (n = 5) or possible (n = 4) HF. The relative risk of HF among TNF-alpha antagonist-treated RA and CD patients was 4.3 and 1.2, respectively (P = NS for both). The absolute difference in cumulative incidence of HF among infliximab or etanercept-exposed compared to unexposed patients was 3.4 and 0.3 cases per 1000 persons for RA and CD (P = NS), respectively, yielding a number needed to harm of 294 for RA and 3333 for CD. **CONCLUSION:** We found only a small number of presumed HF cases (n = 9, or 0.2%) in a large population of relatively young RA and CD patients. Although there was an increased relative risk of incident, HF that was not statistically significant among those exposed to TNF-alpha antagonists compared to those unexposed, larger cohorts are needed to provide more precise risk estimates and permit adjustment.


**BACKGROUND:** The importance of congestive heart failure (CHF) in patients with preserved left ventricular systolic function is increasingly recognized, but most studies have been conducted at a single, usually academic, medical center. The aim of this study was to determine the prognosis, readmission rate, and effect of ACE inhibitor therapy in a Medicare cohort with CHF and preserved systolic function. **METHODS AND RESULTS:** We examined a statewide, random sample of 1,720 California Medicare patients hospitalized with an ICD-9 diagnosis of CHF confirmed by a decreased left ventricular ejection fraction (EF) or chest radiograph from July 1993 to June 1994 and January 1996 to June 1996. Among the 782 patients with confirmed CHF and an in-hospital left ventricular EF measurement, 45% had reduced systolic function (ReSF) (EF 40%). The PrSF group had a lower 1-year mortality rate but similar hospital readmission rates for both CHF and all causes. In patients with ReSF, ACE inhibitor treatment was associated with a lower mortality rate (P =.04) and a trend toward a lower CHF readmission rate (P =.13). In contrast, ACE inhibition therapy was associated with neither a lower rate of mortality nor CHF readmission in PrSF patients (P =.61 and .12, respectively). In multivariate analyses treatment with ACE inhibitors in PrSF patients was not associated with either a reduction in mortality (hazard ratio, 1.15; 95% CI, 0.79-1.67) or CHF readmission (hazard ratio, 1.21; 95% CI, 0.92-1.58). **CONCLUSIONS:** CHF with PrSF seems to be...
associated with high mortality and morbidity rates, but ACE inhibitors may not produce comparable benefit in this group as in patients with ReSF.


This project was designed to improve the in-hospital management of Medicare beneficiaries with congestive heart failure (CHF). Eleven hospitals were studied using two indicators: (a) assessment of left ventricular (LV) function, and (b) use of angiotensin converting enzyme (ACE) inhibitors in patients with systolic dysfunction. Baseline performance rates were obtained for 990 cases with the Diagnosis Related Group (DRG) 127 for CHF discharged January 1994 to December 1994. Baseline data feedback presentations in 1995 spurred quality improvement plans with interventions such as physician education, critical care maps, and standing orders. Follow-up abstractions were performed on 612 discharges October 1995 through April 1997. The study demonstrated 12% improvement (53% to 65%, p < .01) in assessing LV function and 20% improvement (54% to 74%, p < .01) in appropriate ACE inhibitor use. Projects emphasizing Health Care Quality Improvement Program (HCQIP) principles can successfully affect health care management for the Medicare population.


AIMS: Previous epidemiologic studies of acute heart failure (AHF) have involved patients admitted to hospital and fail to account for that unknown proportion discharged directly from the emergency department (ED). We examined discharge rates, and whether outcomes, including mortality, differed based on admission status in AHF. METHODS AND RESULTS: This population-based cohort included all patients > or =65 years presenting to an Alberta ED with HF (ICD9-CM 428.x; 1998 to 2001). Patients were either not admitted (Not-ADM) or directly admitted to hospital (ADM) and followed for one-year. Of 10,415 AHF patients evaluated in the ED, 35% were Not-ADM whereas 65% were ADM. Thirty days after ED presentation the rates of death, re-ED or initial/re-hospitalization were 3.3%, 44% and 19% for Not-ADM, and 10.9%, 33% and 21% for the ADM patients, respectively (all p<0.0001). At one-year, the rates of death, re-ED or initial/re-hospitalization were 20%, 82% and 58% for Not-ADM, and 34%, 72% and 60% for ADM, respectively (all p<0.0001). CONCLUSIONS: One third of AHF patients were not immediately admitted after an ED visit but most present again to the ED, two-thirds were hospitalized and 20% died within the first year. Our findings provide new impetus to undertake risk assessment and treatment strategies in the ED for AHF.


CONTEXT: Whether statin therapy has beneficial effects on clinical outcomes in patients with heart failure is unclear. OBJECTIVE: To evaluate the association between initiation of statin therapy and risks for death and hospitalization among adults with chronic heart failure. DESIGN, SETTING, AND PATIENTS: Propensity-adjusted cohort study of adults diagnosed with heart failure who were eligible for lipid lowering therapy but had no previous known statin use, within an integrated health care delivery system in northern California between January 1, 1996, and December 31, 2004. Statin use was estimated from filled outpatient prescriptions in pharmacy databases. MAIN OUTCOME MEASURES: All-cause death and hospitalization for heart failure during a median of 2.4 years of follow-up. We examined the independent relationships between statin therapy and risks for adverse events overall and stratified by the presence or absence of coronary heart disease after
multivariable adjustment for potential confounders. RESULTS: Among 24,598 adults diagnosed with heart failure who had no prior statin use, those initiating statin therapy (n = 12,648; 51.4%) were more likely to be younger, male, and have known cardiovascular disease, diabetes, and hypertension. There were 8235 patients who died. Using an intent-to-treat approach, incident statin use was associated with lower risks of death (age- and sex-adjusted rate of 14.5 per 100 person-years with statin therapy vs 25.3 per 100 person-years without statin therapy; adjusted hazard ratio, 0.76 [95% confidence interval, 0.72-0.80]) and hospitalization for heart failure (age- and sex-adjusted rate of 21.9 per 100 person-years with statin therapy vs 31.1 per 100 person-years without statin therapy; adjusted hazard ratio, 0.79 [95% confidence interval, 0.74-0.85]) even after adjustment for the propensity to take statins, cholesterol level, use of other cardiovascular medications, and other potential confounders. Incident statin use was associated with lower adjusted risks of adverse outcomes in patients with or without known coronary heart disease. CONCLUSION: Among adults diagnosed with heart failure who had no prior statin use, incident statin use was independently associated with lower risks of death and hospitalization among patients with or without coronary heart disease.


BACKGROUND: Congestive heart failure (CHF) is increasing as a public health problem in the United States. The ability to quantify this problem has been limited by a lack of data regarding the validity of CHF identification. OBJECTIVE: To assess the validity of the use of International Classification of Diseases, Ninth Revision, Clinical Modification (ICD) codes to identify hospitalizations with clinical evidence of an episode of acute CHF in data of The Corpus Christi Heart Project, a population-based surveillance program for hospitalized coronary heart disease. METHODS: The validation standard was a composite variable including the presence of physician diagnosed acute CHF or radiographic evidence of pulmonary edema. Data were abstracted from the medical records of 5083 patients identified as hospitalized for possible acute myocardial infarction, aortocoronary bypass surgery, percutaneous transluminal coronary angioplasty, and related revascularization procedures in the Corpus Christi Heart Project. Discharge diagnoses, a secondary source of data, were used to apply 3 computer algorithms to assess the assignment of ICD codes. RESULTS: The prevalence of clinically documented CHF was 27.1% (1376/5083). The ICD code 428 (CHF), assigned as the primary or a secondary discharge diagnosis, was associated with 62.8% sensitivity, 95.4% specificity, 83.5% positive predictive value, 87.4% negative predictive value, and a 24.8% underenumeration of CHF-related hospitalizations. An algorithm based on a series of ICD codes was associated with 67.1% sensitivity, 92.6% specificity, 77.1% positive predictive value, 88.3% negative predictive value, and a 13.0% underenumeration of CHF-related hospitalizations. CONCLUSIONS: Reliance on ICD codes results in the exclusion of one third of the patients with clinical evidence of acute CHF. This underenumeration is compounded by the typical reliance on the first listed diagnosis. Congestive heart failure may be a greater public health problem than currently recognized. The allocation of resources for relevant surveillance, research, medical care, and preventive efforts should be reevaluated.

PURPOSE: Computerized definitions are used to identify serious infections and congestive heart failure leading to hospitalizations in studies of medication safety. However, information on their accuracy is limited. We evaluated the ability of computerized definitions to identify these conditions as the reason for admission among patients diagnosed with rheumatoid arthritis (RA). METHODS: Medical charts were randomly selected from a systematic sample of hospitalizations for selected conditions in a cohort of Medicaid patients with RA. We calculated positive predictive values (PPVs) for computerized definitions for community-acquired pneumonia, invasive pneumococcal disease, sepsis, opportunistic mycoses, and congestive heart failure using charts reviews as gold standard and computed inter-reviewer agreement statistics. RESULTS: From 2667 hospitalizations, 336 (13%) records were selected for review. A total of 277 charts (82%) were available. Based on any discharge diagnosis, PPVs for hospitalizations due to community-acquired pneumonia, invasive pneumococcal disease, sepsis, and opportunistic mycoses were 84, 100, 80, and 62%, respectively. Restricting definitions to principal diagnoses yielded higher PPVs, 95% for pneumonia and 100% for other diagnoses. The PPV of a principal diagnosis for congestive heart failure was 100%. Inter-reviewer agreement was at least 77% for all outcomes. CONCLUSION: These findings suggest that computerized definitions can identify congestive heart failure and selected infections leading to hospitalization in Medicaid patients with RA.


BACKGROUND: The elderly make up the majority of patients with heart failure (HF), but information on this segment of the HF population is lacking because clinical trials typically enroll younger patients and population-based studies lack clinical detail. We sought to describe a contemporary national sample of elderly patients with HF and to examine the sample for age-related trends in clinical characteristics. METHODS: We studied the charts of 800 Medicare patients per state who were hospitalized with a principal diagnosis of HF between April 1998 and March 1999. There were 34,587 patients in the sample after exclusion of patients who were <65 years old, repeat discharges, discharges to another acute care facility or against medical advice, or receiving long-term hemodialysis. RESULTS: Comorbidity was common. About one third of patients had chronic obstructive pulmonary disease, about 40% had diabetes, more than half had coronary heart disease, and more than half had a history of hypertension, but comorbidity rates declined with age. Left ventricular ejection fraction was <40% in only 50.4% of patients in whom it was assessed. Associated laboratory abnormalities were relatively constant across the age spectrum, but renal insufficiency was more common with advancing age. The likelihood that patients were in long-term care facilities before admission rose quite steeply with age. CONCLUSIONS: Elderly patients with HF are a heterogeneous group and appear to differ substantially from patients enrolled in clinical trials. Evidence-based guidance for treatment in the context of multiple comorbid conditions, poor renal function, HF with preserved left ventricular systolic function, and residence in long-term care facilities is urgently needed.


BACKGROUND: Glycemic control is associated with microvascular events, but its effect on the risk of heart failure is not well understood. We examined the association between hemoglobin (Hb) A(1c) and the risk of heart failure hospitalization and/or death in a population-based sample of adult patients with diabetes and assessed whether this association differed by patient sex, heart failure pathogenesis, and hypertension status. METHODS AND RESULTS: A cohort design was used with
baseline between January 1, 1995, and June 30, 1996, and follow-up through December 31, 1997 (median 2.2 years). Participants were 25,958 men and 22,900 women with (predominantly type 2) diabetes, ≥19 years old, with no known history of heart failure. There were a total of 935 events (516 among men; 419 among women). After adjustment for age, sex, race/ethnicity, education level, cigarette smoking, alcohol consumption, hypertension, obesity, use of beta-blockers and ACE inhibitors, type and duration of diabetes, and incidence of interim myocardial infarction, each 1% increase in Hb A(1c) was associated with an 8% increased risk of heart failure (95% CI 5% to 12%). An Hb A(1c) ≥10, relative to Hb A(1c) <7, was associated with 1.56-fold (95% CI 1.26 to 1.93) greater risk of heart failure. Although the association was stronger in men than in women, no differences existed by heart failure pathogenesis or hypertension status. CONCLUSIONS: These results confirm previous evidence that poor glycemic control may be associated with an increased risk of heart failure among adult patients with diabetes.


OBJECTIVE: To determine the suitability of insurance claims information for use in clinical outcomes research in ischemic heart disease. DESIGN: Concordance study of two databases. SETTING: Tertiary care referral center. PATIENTS: A total of 12,937 consecutive patients hospitalized for cardiac catheterization for suspected ischemic heart disease between July 1985 and May 1990. INTERVENTIONS: Two-by-two tables were used to compute overall and kappa measures of agreement comparing clinical versus claims data for 12 important predictors of prognosis in patients with ischemic heart disease. MEASUREMENTS: Kappa statistics (agreement adjusted for chance agreement) were used to quantify agreement rates. RESULTS: Agreement rates between the clinical and claims databases ranged from 0.83 for the diagnosis of diabetes to 0.09 for the diagnosis of unstable angina (kappa values). Claims data failed to identify more than one half of the patients with prognostically important conditions, including mitral insufficiency, congestive heart failure, peripheral vascular disease, old myocardial infarction, hyperlipidemia, cerebrovascular disease, tobacco use, angina, and unstable angina, when compared with the clinical information system. CONCLUSIONS: Our results suggest that insurance claims data lack important diagnostic and prognostic information when compared with concurrently collected clinical data in the study of ischemic heart disease. Thus, insurance claims data are not as useful as clinical data for identifying clinically relevant patient groups and for adjusting for risk in outcome studies, such as analyses of hospital mortality.


BACKGROUND: It is not known whether subspecialty care by cardiologists improves outcomes in heart failure patients from the community over care by other physicians. METHODS AND RESULTS: Using administrative data, we monitored 38,702 consecutive patients with first time hospitalization for heart failure in Ontario, Canada, between April 1994 and March 1996 and examined differences in processes of care and clinical outcomes between patients attended by physicians of different disciplines. We found that patients attended by cardiologists had lower 1-year risk-adjusted mortality than those attended by general interns, family practitioners, and other physicians (28.5% versus 31.7%, 34.9%, and 35.9%, respectively; all pairwise comparisons, P<0.001). The 1-year risk-adjusted composite outcome of death and readmission for heart failure was also lower for the
cardiologists compared with family practitioners and other physicians but not general internists (54.7% versus 58.1%, 58.3%, and 55.4%; P<0.001, P<0.001, and P=0.39, respectively). Multivariable hierarchical modeling demonstrated a significant physician level effect for both outcomes in favor of the cardiologists, particularly against nongeneral internists. Cardiologist care was associated with higher adjusted rates of invasive interventions and postdischarge prescriptions of heart failure medications. CONCLUSIONS: In this population-based cohort, heart failure patients attended by cardiologists in hospital had lower risk of death as well as the composite risk of death or readmission than patients attended by noncardiologists. These data raise the need to identify specialty driven differences in processes of care for heart failure patients, which may explain the observed disparity in clinical outcomes that presently favor cardiologist care.


Myocardial damage from heavy alcohol intake can cause the heart failure (HF) syndrome, but the relation of lighter alcohol intake to HF has rarely been studied. We examined the risk of HF hospitalization among 126,236 subjects who supplied data about alcohol during health examinations from 1978 to 1985. Among 2,594 subjects who were subsequently hospitalized for HF, record review established an association between coronary artery disease (CAD) and HF (CAD-HF) in 1,559 patients. Among the remaining 1,035 subjects who had HF (non-CAD-HF), we attempted determination of preponderant etiologic and contributory factors. Analyses used Cox models that were controlled for 7 covariates, with usual alcohol intake studied categorically compared with that in subjects who did not drink alcohol. Heavier drinkers (> or =3 drinks/day) but not light to moderate drinkers had increased risk of non-CAD-HF; e.g., relative risk for subjects who reported > or =6 drinks/day was 1.7 (95% confidence interval 1.1 to 2.6). This association of non-CAD-HF with heavy drinking was limited to subsets with cardiomyopathy or of unclear preponderant etiology. Alcohol drinking was inversely related to risk of CAD-HF (e.g., at 1 to 2 drinks/day, relative risk 0.6, 95% confidence interval 0.5 to 0.7), with consistency across subgroups of age, gender, ethnicity, education, smoking status, interval to diagnosis, and presence or absence of baseline heart disease or systemic hypertension. Moderate drinking was inversely related to non-CAD-HF only in subjects who had diabetes mellitus (n = 252). In conclusion, heavy, but not light, alcohol drinking is associated with increased risk of non-CAD-HF and that apparent protection by alcohol drinking against CAD-HF risk provides confirmation of a protective effect of alcohol against CAD.


BACKGROUND: Despite the potential usefulness of administrative databases for evaluating outcomes, coding of heart failure and associated comorbidities have not been definitively compared with clinical data. OBJECTIVE: To compare the predictive value of heart failure diagnoses and secondary conditions identified in a large administrative database with chart-based records. METHODS: The authors studied 1808 patient records sampled from 14 acute care hospitals and compared clinically recorded data with administrative records from the Canadian Institute for Health Information. The impact of comorbidity coding in the administrative data set according to the Charlson classification was examined in models of 30-day mortality. RESULTS: The positive predictive value (PPV) of a primary diagnosis ICD-9 428 was 94.3% using the Framingham criteria and 88.6% using criteria previously validated with pulmonary capillary wedge pressure. There was reduced prevalence of secondary comorbid conditions in administrative data in comparison with clinical chart data. The specificities and PPV/negative predictive values of administratively identified index
Comorbidities were high. The sensitivities of index comorbidities were low, but were enhanced by examination of hospitalizations within 1 year prior to the index heart failure admission. Using information from prior hospitalizations modestly enhanced 30-day mortality model performance; however, the odds ratio point estimates of the index and enhanced administrative data sets were consistent with the clinical model. CONCLUSION: The ICD-9 428 primary diagnosis is highly predictive of heart failure using clinical criteria. Examination of hospitalization data up to 1 year prior to the index admission improves comorbidity detection and may provide enhancements to future studies of heart failure mortality.

Lee WY, Capra AM, Jensvold NG, Gurwitz JH, Go AS. Epidemiology, Practice, Outcomes, and Cost of Heart Failure (EPOCH) Study. Gender and risk of adverse outcomes in heart failure. Am J Cardiol. 2004 Nov 1; 94(9): 1147-52.

Congestive heart failure (CHF) is the leading cause of hospitalization in the elderly, and these patients are at high risk for subsequent hospitalization. Whether gender affects the risk of rehospitalization in patients who have CHF is less well understood. We studied a random sample of 1,700 adults who had been hospitalized with CHF (from July 1, 1999 to June 30, 2000) and identified all readmissions through June 30, 2001. We used proportional hazards regression to evaluate whether gender affects the risk of all-cause and CHF-specific rehospitalization, after adjusting for differences in demographic characteristics, health-related behaviors, co-morbid conditions, left ventricular systolic function status, and use of CHF therapies. Among 1,591 adults who had confirmed CHF, 752 were women (47.3%). Women were older than men (73 vs 71 years, p <0.001) and more likely to have preserved systolic function (55.3% vs 40.9%, p <0.001), hypertension (83.1% vs 75.2%, p <0.001), and prior renal insufficiency (46.8% vs 34.6%, p <0.001). No significant differences existed between women and men with respect to crude rates of any readmission (144.7 vs 134.6 per 100 person-years, p = 0.36) or CHF-specific readmission (39.9 vs 37.4 per 100 person-years, p = 0.65). After adjusting for potential confounders, there was no significant difference between women and men with respect to risk of any readmission (adjusted hazard ratio 0.88, 95% confidence interval 0.76 to 1.02) or readmission for CHF (adjusted hazard ratio 0.89, 95% confidence interval 0.71 to 1.11). Among a contemporary, diverse population of patients who had CHF, rates of readmission overall and for CHF remained high, but gender was not independently associated with a differential risk of readmission.


BACKGROUND AND OBJECTIVES: Billing claims are increasingly examined beyond administrative functions as outcomes measures in observational research. Few studies have described the performance of billing claims as surrogate measures of clinical events among kidney transplant recipients. DESIGN, SETTING, PARTICIPANTS, & MEASUREMENTS: We investigated the sensitivity of Medicare billing claims for clinically verified cardiovascular diagnoses (five categories) and procedures (four categories) in a novel database linking Medicare claims to electronic medical records of one transplant program. Cardiovascular events identified in medical records for 571 Medicare-insured transplant recipients in 1991 through 2002 served as reference measures. RESULTS: Within a claims-ascertainment period spanning +/-30 d of clinically recorded dates, aggregate sensitivity of single claims was higher for case definitions incorporating Medicare Parts A and B for diagnoses and procedures (90.9%) compared with either Part A (82.3%) or Part B (84.6%) alone. Perfect capture of the four procedures was possible within +/-30 d or with short claims
window expansion, but sensitivity for the diagnoses trended lower with all study algorithms (91.2% with window up to +/-90 d). Requirement for additional confirmatory diagnosis claims did not appreciably reduce sensitivity. Sensitivity patterns were similar in the early compared with late periods of the study. CONCLUSIONS: Combined use of Medicare Parts A and B billing claims composes a sensitive measure of cardiovascular events after kidney transplant. Further research is needed to define algorithms that maximize specificity as well as sensitivity of claims from Medicare and other insurers as research measures in this population.


OBJECTIVES: The purpose of this study was to create an automated surveillance tool for reporting the incidence, prevalence and processes of care for patients with heart failure. BACKGROUND: Previous epidemiologic studies suggest that the increasing prevalence of heart failure is a consequence of improved survival coupled with minimal changes in disease prevention. Developing new, efficient methods of assessing the incidence and prevalence of heart failure could allow continued surveillance of these rates during an era of rapidly changing treatments and health care delivery patterns. METHODS: Using administrative data sets, we created a definition of heart failure using diagnosis codes. After adjustment for patients leaving our health system or death, we derived the incidence, prevalence and mortality of the population with heart failure from 1989 to 1999. RESULTS: A total of 29,686 patients of all ages, 52.6% women and 47.4% men, met the definition of heart failure. Mean ages were 71.1 +/- 14.5 for women and 67.7 +/- 14.4 for men, p < 0.0001. Race proportions were 50.5% white, 44.6% African American and 4.9% other race. Incidence rates were higher in men and African Americans across all age groups. There was an annual increase in prevalence of 1/1,000 for women and 0.9/1,000 for men, p = 0.001 for both trends. CONCLUSIONS: Through the feasible and valid use of automated data, we have confirmed a chronic disease epidemic of heart failure manifested primarily by an increase in prevalence over the past decade. Our surveillance system mirrors the results of epidemiologic studies and may be a valid method for monitoring the impact of prevention and treatment programs.


BACKGROUND: The prevalence of heart failure with preserved ejection fraction may be changing as a result of changes in population demographics and in the prevalence and treatment of risk factors for heart failure. Changes in the prevalence of heart failure with preserved ejection fraction may contribute to changes in the natural history of heart failure. We performed a study to define secular trends in the prevalence of heart failure with preserved ejection fraction among patients at a single institution over a 15-year period. METHODS: We studied all consecutive patients hospitalized with decompensated heart failure at Mayo Clinic Hospitals in Olmsted County, Minnesota, from 1987 through 2001. We classified patients as having either preserved or reduced ejection fraction. The patients were also classified as community patients (Olmsted County residents) or referral patients. Secular trends in the type of heart failure, associated cardiovascular disease, and survival were defined. RESULTS: A total of 6076 patients with heart failure were discharged over the 15-year period; data on ejection fraction were available for 4596 of these patients (76 percent). Of these, 53 percent had a reduced ejection fraction and 47 percent had a preserved ejection fraction. The proportion of patients with the diagnosis of heart failure with preserved ejection fraction increased over time and was significantly higher among community patients than among referral patients (55 percent vs 45 percent). The prevalence rates of hypertension, atrial fibrillation, and diabetes among
patients with heart failure increased significantly over time. Survival was slightly better among patients with preserved ejection fraction (adjusted hazard ratio for death, 0.96; P=0.01). Survival improved over time for those with reduced ejection fraction but not for those with preserved ejection fraction. CONCLUSIONS: The prevalence of heart failure with preserved ejection fraction increased over a 15-year period, while the rate of death from this disorder remained unchanged. These trends underscore the importance of this growing public health problem.

We used administrative (Part A Medicare) data to identify a representative sample of 1126 patients with congestive heart failure and 1150 with acute myocardial infarction in hospitals with significant unexpectedly high inpatient, age-sex-disease-specific death rates ("targeted") vs all other ("untargeted") hospitals in four states. Although death rates in targeted hospitals were 5.0 to 10.9 higher per 100 admissions than in untargeted hospitals, 56% to 82% of the excess could result from purely random variation. Differences in the quality of the process of care (based on a medical record review) could not explain the remaining statistically significant differences in mortality. Comparing targeted hospitals with subsets of untargeted ones, e.g., those with lower than expected death rates, did not affect this conclusion. Severity of illness explained up to 2.8 excess deaths per 100 admissions for patients with myocardial infarction. Identifying hospitals that provide poor quality care based on administrative data and single-year death rates is unlikely; targeting based on time periods greater than 1 year may be better.

Race and gender are important determinants of certain clinical outcomes in cardiovascular disease. To examine the influence of race and gender on care process, resource use, and hospital-based case outcomes for patients with congestive heart failure (CHF), we obtained administrative records on all 1995 New York State hospital discharges assigned ICD-9-CM codes indicative of this diagnosis. The following were compared among black and white women and men: demographics, comorbid illness, care processes, length of stay (LOS), hospital charges, mortality rate, and CHF readmission rate. We identified 45,894 patients (black women, 4,750; black men, 3,370; white women, 21,165; white men, 16,609). Blacks underwent noninvasive cardiac procedures more often than whites; procedure and specialty use rates were lower among women than among men. After adjusting for other patient characteristics and hospital type and location, we found race to be an important determinant of LOS (black, 10.4 days; white, 9.3 days; p = 0.0001), hospital charges (black, $13,711; white, $11,074; p = 0.0001), mortality (black-to-white odds ratio = 0.832; p = 0.003), and readmission (black-to-white odds ratio = 1.301; p = 0.0001). Gender was an important determinant of LOS (women, 9.8 days; men, 9.2 days; p = 0.0001), hospital charges (women, $11,690; men, $11,348; p = 0.02), and mortality (women-to-men odds ratio = 0.878; p = 0.0008). We conclude that race and gender influence care process and hospital-based case outcomes for patients with CHF.

BACKGROUND: Little is known about the actual determinants of hospital length of stay (LOS) among patients admitted with congestive heart failure (CHF), in spite of its economic impact. To increase understanding of these factors, we examined the demographic, clinical, laboratory, and treatment characteristics of patients hospitalized with decompensated CHF. METHODS: The charts of
consecutive patients admitted to 10 acute care community hospitals during 1995 were reviewed. The relationship between LOS and more than 140 patient-specific variables were examined. First, patient characteristics identifiable within the first 24 hours of hospitalization were examined for their relationship with LOS. Then, variables indicative of the processes of care and response to treatment were studied. Finally, administrative data were added to yield the final model for LOS.

RESULTS: During the study period 1402 patients were admitted to the participating centers. The patients were predominantly elderly with moderately severe or severe CHF. With stepwise multiple linear regression, 5% of the variation in LOS could be explained by baseline characteristics alone (r = 0.22, p < 0.0001). When treatment and response variables were added to this model, 15% of the variation in LOS could be explained (r = 0.39, p < 0.0001). When administrative data were added, the final model explained 31% of the variation in LOS (r = 0.56, p < 0.0001). CONCLUSIONS: We conclude that LOS among patients hospitalized with decompensated CHF is partially related to patient demographics, severity of illness, management modalities, response to treatment, and administrative data. However, significant residual variation in LOS exists, which cannot be explained by these factors. These observations may be of value in the design and implementation of initiatives aimed at reducing resource utilization and improving quality of care in CHF.


BACKGROUND: The comorbidity variables that constitute the Charlson index are widely used in health care research using administrative data. However, little is known about the validity of administrative data in these comorbidities. The agreement between administrative hospital discharge data and chart data for the recording of information on comorbidity was evaluated. The predictive ability of comorbidity information in the two data sets for predicting in-hospital mortality was also compared. METHODS: One thousand two hundred administrative hospital discharge records were randomly selected in the region of Calgary, Alberta, Canada in 1996 and used a published coding algorithm to define the 17 comorbidities that constitute the Charlson index. Corresponding patient charts for the selected records were reviewed as the "criterion standard" against which validity of the administrative data were judged. RESULTS: Compared with the chart data, administrative data had a lower prevalence in 10 comorbidities, a higher prevalence in 3 and a similar prevalence in 4. The kappa values ranged from a high of 0.87 to a low of 0.34; agreement was therefore near perfect for one variable, substantial for six, moderate for nine, and only fair for one variable. For the Charlson index score ranging from 0 to 5 to 6 or higher, agreement was moderate to substantial (kappa = 0.56, weighted kappa = 0.71). When 16 Charlson comorbidities from administrative data were used to predict in-hospital mortality, 10 comorbidities and the index scores defined using administrative data yielded odds ratios that were similar to those derived from chart data. The remaining six comorbidities yielded odds ratios that were quite different from those derived from chart data. CONCLUSIONS: Administrative data generally agree with patient chart data for recording of comorbidities although comorbidities tend to be under-reported in administrative data. The ability to predict in-hospital mortality is less reliable for some of the individual comorbidities than it is for the summarized Charlson index scores in administrative data.


OBJECTIVE: To evaluate the effect of a mental illness diagnosis on quality of care and outcomes among patients with heart failure. DESIGN: Retrospective, national, population-based sample of
patients with heart failure hospitalized from April 1, 1998, through March 31, 1999, and July 1, 2000, through June 30, 2001. SETTING: Nonfederal US acute care hospitals. PATIENTS: A total of 53,314 Medicare beneficiaries. MAIN OUTCOME MEASURES: Quality of care measures, including left ventricular ejection fraction (LVEF) assessment, prescription of an angiotensin-converting enzyme (ACE) inhibitor at discharge among patients without treatment contraindications, and 1-year readmission and 1-year mortality. RESULTS: Of the patients included in the study, 17.0% had a mental illness diagnosis. Compared with patients without mental illness diagnoses, eligible patients with mental illness diagnoses had lower rates of LVEF evaluation (53.0% vs 47.3%; P < .001) but comparable rates of ACE inhibitor prescription (71.3% vs 69.7%; P = .40). Findings were unchanged after multivariate adjustment: patients with mental illness had lower odds of LVEF evaluation (odds ratio [OR], 0.81; 95% confidence interval [CI], 0.76-0.87) but comparable rates of ACE inhibitor prescription (OR, 0.96; 0.80-1.14). Patients with mental illness diagnoses had higher crude rates of 1-year all-cause readmission (73.7% vs 68.5%; P < .001), which persisted after multivariate adjustment (OR, 1.30; 95% CI, 1.21-1.39). Crude 1-year mortality was higher among patients with a mental illness diagnosis (41.0% vs 36.2%; P < .001). Presence of a comorbid mental illness diagnosis was associated with 1-year mortality after multivariate adjustment (OR, 1.20; 95% CI, 1.12-1.28).

CONCLUSIONS: Mental illness is commonly diagnosed among elderly patients hospitalized with heart failure. This subgroup receives somewhat poorer care during hospitalization and has a greater risk of death and readmission to the hospital.


Although congestive heart failure is a fairly common clinical syndrome and the societal costs associated with its care are high, relatively little is known about the incidence or prevalence of the condition in the community. Using the resources of the Rochester Epidemiology Project, we identified all 46 persons 0 through 74 years of age who had a new diagnosis of congestive heart failure during 1981 and all 113 persons with a prevalent diagnosis on Jan. 1, 1982, in the city of Rochester, Minnesota. After confirming the diagnosis in the medical record by using criteria similar to those in the Framingham study, we found the annual incidence of congestive heart failure to be 110 per 100,000 after adjusting for age. Incidence rates were higher among male than among female study subjects (157 versus 71 per 100,000). In both male and female subjects, the incidence generally increased with advancing age, reaching 1,618 per 100,000 and 981 per 100,000, respectively. Prevalence rates on Jan. 1, 1982, demonstrated similar patterns. Overall, the prevalence of congestive heart failure was higher among male than among female subjects (327 versus 214 per 100,000) and increased exponentially with advancing age, reaching almost 3% in both sexes. Survival after a diagnosis of congestive heart failure was extremely poor, with only 80% alive at 3 months and 66% at 1 year. These data underscore the effect of congestive heart failure in the community and provide estimates of the number of persons who might benefit from early intervention.


CONTEXT: The epidemic of heart failure has yet to be fully investigated, and data on incidence, survival, and sex specific temporal trends in community-based populations are limited. OBJECTIVE: To test the hypothesis that the incidence of heart failure has declined and survival after heart failure diagnosis has improved over time but that secular trends have diverged by sex. DESIGN, SETTING, AND PARTICIPANTS: Population-based cohort study using the resources of the Rochester
Epidemiology Project conducted in Olmsted County, Minnesota. Patients were 4537 Olmsted County residents (57% women; mean [SD] age, 74 [14] years) with a diagnosis of heart failure between 1979 and 2000. Framingham criteria and clinical criteria were used to validate the diagnosis. MAIN OUTCOME MEASURES: Incidence of heart failure and survival after heart failure diagnosis. RESULTS: The incidence of heart failure was higher among men (378/100 000 persons; 95% confidence interval [CI], 361-395 for men; 289/100 000 persons; 95% CI, 277-300 for women) and did not change over time among men or women. After a mean follow-up of 4.2 years (range, 0-23.8 years), 3347 deaths occurred, including 1930 among women and 1417 among men. Survival after heart failure diagnosis was worse among men than women (relative risk, 1.33; 95% CI, 1.24-1.43) but overall improved over time (5-year age-adjusted survival, 43% in 1979-1984 vs 52% in 1996-2000, P<.001). However, men and younger persons experienced larger survival gains, contrasting with less or no improvement for women and elderly persons. CONCLUSION: In this community-based cohort, the incidence of heart failure has not declined during 2 decades, but survival after onset of heart failure has increased overall, with less improvement among women and elderly persons.


PURPOSE: We compared hospitalized congestive heart failure (CHF) incidence and prognosis estimates using hospital discharge diagnoses or central adjudication. METHODS: We used the Cardiovascular Health Study (CHS), a population-based cohort study of 5888 elderly adults. A physician committee adjudicated potential CHF events, confirmed by signs, symptoms, clinical tests, and/or medical therapy. A CHF discharge diagnosis included any of these ICD-9 codes in any position: 428, 425, 398.91, 402.01, 402.11, 402.91, and 997.1. We constructed an inception cohort of 1209 hospitalized, nonfatal, incident CHF cases, identified by discharge diagnosis, adjudication, or both. RESULTS: Incidence rates for hospitalized CHF were 24.6 per 1000 person-years using discharge diagnoses and 17.1 per 1000 person-years using central adjudication. Compared to the group identified as having CHF by both methods, the group with only a discharge diagnosis (hazard ratio=0.77, 95% confidence interval=0.65-0.91) and the group with central adjudication only (hazard ratio=0.72, 95% confidence interval=0.55-0.94) had lower mortality rates. CONCLUSIONS: In the elderly, studies using only discharge diagnoses, as compared to central adjudication, may estimate higher rates of incident hospitalized CHF. Mortality following CHF onset may be similar for these methods and higher if both methods are used together.

So L, Evans D, Quan H. ICD-10 coding algorithms for defining comorbidities of acute myocardial infarction. BMC Health Serv Res. 2006 Dec 15; 6: 161.

BACKGROUND: With the introduction of ICD-10 throughout Canada, it is important to ensure that Acute Myocardial Infarction (AMI) comorbidities employed in risk adjustment methods remain valid and robust. Therefore, we developed ICD-10 coding algorithms for nine AMI comorbidities, examined the validity of the ICD-10 and ICD-9 coding algorithms in detection of these comorbidities, and assessed their performance in predicting mortality. The nine comorbidities that we examined were shock, diabetes with complications, congestive heart failure, cancer, cerebrovascular disease, pulmonary edema, acute renal failure, chronic renal failure, and cardiac dysrhythmias. METHODS: Coders generated a comprehensive list of ICD-10 codes corresponding to each AMI comorbidity. Physicians independently reviewed and determined the clinical relevance of each item on the list. To ensure that the newly developed ICD-10 coding algorithms were valid in recording comorbidities, medical charts were reviewed. After assessing ICD-10 algorithms' validity, both ICD-10 and ICD-9...
algorithms were applied to a Canadian provincial hospital discharge database to predict in-hospital, 30-day, and 1-year mortality. RESULTS: Compared to chart review data as a 'criterion standard', ICD-9 and ICD-10 data had similar sensitivities (ranging from 7.1-100%), and specificities (above 93.6%) for each of the nine AMI comorbidities studied. The frequencies for the comorbidities were similar between ICD-9 and ICD-10 coding algorithms for 49,861 AMI patients in a Canadian province during 1994-2004. The C-statistics for predicting 30-day and 1 year mortality were the same for ICD-9 (0.82) and for ICD-10 data (0.81). CONCLUSION: The ICD-10 coding algorithms developed in this study to define AMI comorbidities performed similarly as past ICD-9 coding algorithms in detecting conditions and risk-adjustment in our sample. However, the ICD-10 coding algorithms should be further validated in external databases.
B. APPENDIX B: LIST OF CITATIONS SELECTED FOR FULL-TEXT REVIEW BUT NOT INCLUDED, BY REASONS FOR EXCLUSION

1. Studies Excluded Because Article Not Located/Reviewed


2. Studies Excluded Because Did Not Study HOI


3. **Studies Excluded Because Not Administrative Database Study**


Borlaug BA, Lam CS, Roger VL, Rodeheffer RJ, Redfield MM. Contractility and ventricular systolic stiffening in hypertensive heart disease insights into the pathogenesis of heart failure with


Yamani MH. When should digoxin be used in patients with diastolic dysfunction? *Cleveland Clinic Journal of Medicine.* Jun 2001; 68(6): 481, 485.

4. **Studies Excluded Because Not From the United States or Canada**


5. **Studies Excluded Due to Poorly Defined Algorithms**


Sweitzer NK, Lopatin M, Yancy CW, Mills RM, Stevenson LW. Comparison of clinical features and outcomes of patients hospitalized with heart failure and normal ejection fraction (> or =55%) versus those with mildly reduced (40% to 55%) and moderately to severely reduced (<40%) fractions. *The American Journal of Cardiology*. Apr 15 2008; 101(8): 1151-1156.


6. Studies Excluded Due to Lack of Validation or Reporting of Validation Statistics


From AM, Scott CG, Chen HH. The development of heart failure in patients with diabetes mellitus and pre-clinical diastolic dysfunction a population-based study. *Journal of the American College of Cardiology.* Jan 26; 55(4): 300-305.


Joshi AV, D’Souza AO, Madhavan SS. Differences in hospital length-of-stay, charges, and mortality in congestive heart failure patients. *Congestive Heart Failure (Greenwich, Conn.)* Mar-Apr 2004; 10(2): 76-84.


Roe CM, Motheral BR, Teitelbaum F, Rich MW. Compliance with and dosing of angiotensin-
converting-enzyme inhibitors before and after hospitalization. *American Journal of Health-
System Pharmacy: AJHP: Official Journal of the American Society of Health-System

and 30-day standardized hospital mortality: implications for profiling hospitals. *Health

Ross JS, Normand SL, Wang Y, et al. Hospital volume and 30-day mortality for three common

Sandgren PE, Murray AM, Herzog CA, et al. Anemia and new-onset congestive heart failure in the

Schmedtje JF, Jr., Evans GW, Byerly W, et al. Treatment of chronic heart failure in a managed care
setting. Baseline results from the Achieving Cardiac Excellence Project. *North Carolina
Medical Journal*. Jan-Feb 2003; 64(1): 4-10.

Setoguchi S, Levin R, Winkelmaier WC. Long-term trends of angiotensin-converting enzyme inhibitor
and angiotensin-receptor blocker use after heart failure hospitalization in community-

Setoguchi S, Nohria A, Rassen JA, Stevenson LW, Schneeweiss S. Maximum potential benefit of
implantable defibrillators in preventing sudden death after hospital admission because of
heart failure. *CMAJ: Canadian Medical Association Journal (Journal de L'Association

Setoguchi S, Stevenson LW, Schneeweiss S. Repeated hospitalizations predict mortality in the

Shah KB, Rao K, Sawyer R, Gottlieb SS. The adequacy of laboratory monitoring in patients treated
with spironolactone for congestive heart failure. *Journal of the American College of

blockers on survival in patients >or=65 years of age with heart failure and preserved left
222.

Shenkman HJ, Pampati V, Khandelwal AK, et al. Congestive heart failure and QRS duration:

Sheppard R, Behlouli H, Richard H, Pilote L. Effect of gender on treatment, resource utilization, and
outcomes in congestive heart failure in Quebec, Canada. *The American Journal of


VanSuch M, Naessens JM, Stroebel RJ, Huddleston JM, Williams AR. Effect of discharge instructions on readmission of hospitalized patients with heart failure: do all of the Joint Commission on


7. Studies Excluded Because Evaluated the Same Study Population as Another Study Included in the Evidence Table


### APPENDIX C: LIST AND DEFINITIONS OF ICD OR PROCEDURAL CODES INCLUDED IN ALGORITHMS

<table>
<thead>
<tr>
<th>Type of Code</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRG</td>
<td>124</td>
<td>CIRCULATORY DISORDERS OTHER THAN ACUTE MYOCARDIAL INFARCTION WITH CARDIACE CATHETERIZATION AND COMPLEX DIAGNOSIS</td>
</tr>
<tr>
<td>DRG</td>
<td>127</td>
<td>HEART FAILURE AND SHOCK</td>
</tr>
<tr>
<td>ICD-8</td>
<td>427</td>
<td>SYMPTOMATIC HEART DISEASE</td>
</tr>
<tr>
<td>ICD-9</td>
<td>398.91</td>
<td>RHEUMATIC HEART FAILURE</td>
</tr>
<tr>
<td>ICD-9</td>
<td>402.01</td>
<td>MAL HYPERT HRT DIS W HF</td>
</tr>
<tr>
<td>ICD-9</td>
<td>402.1</td>
<td>BENIGN HYPERTENS HT DIS</td>
</tr>
<tr>
<td>ICD-9</td>
<td>402.11</td>
<td>BENIGN HYP HT DIS W HF</td>
</tr>
<tr>
<td>ICD-9</td>
<td>402.91</td>
<td>HYP HT DIS NOS W HT FAIL</td>
</tr>
<tr>
<td>ICD-9</td>
<td>404.00</td>
<td>MAL HY HT/REN W/O CHF/RF</td>
</tr>
<tr>
<td>ICD-9</td>
<td>404.01</td>
<td>MAL HYP HRT/KIDNEY W HF</td>
</tr>
<tr>
<td>ICD-9</td>
<td>404.03</td>
<td>MAL HYP HRT/KID W HF/KID</td>
</tr>
<tr>
<td>ICD-9</td>
<td>404.10</td>
<td>BEN HY HT/REN W/O CHF/RF</td>
</tr>
<tr>
<td>ICD-9</td>
<td>404.11</td>
<td>BEN HYP HRT/KID W HF</td>
</tr>
<tr>
<td>ICD-9</td>
<td>404.12</td>
<td>BEN HY HT/KID ST V W/O HF</td>
</tr>
<tr>
<td>ICD-9</td>
<td>404.13</td>
<td>BEN HYP HT/KID W HF/KID</td>
</tr>
<tr>
<td>ICD-9</td>
<td>404.90</td>
<td>HY HT/REN NOS W/O CHF/RF</td>
</tr>
<tr>
<td>ICD-9</td>
<td>404.91</td>
<td>HYP HRT/KID NOS W HF</td>
</tr>
<tr>
<td>ICD-9</td>
<td>404.93</td>
<td>HYP HRT/KID NOS W HF/KID</td>
</tr>
<tr>
<td>ICD-9</td>
<td>Code</td>
<td>Description</td>
</tr>
<tr>
<td>-------</td>
<td>-------</td>
<td>------------------------------------</td>
</tr>
<tr>
<td>414.8</td>
<td>CHR ISCHEMIC HRT DIS NEC</td>
<td></td>
</tr>
<tr>
<td>415.0</td>
<td>ACUTE COR PULMONALE</td>
<td></td>
</tr>
<tr>
<td>416.9</td>
<td>CHR PULMON HEART DIS NOS</td>
<td></td>
</tr>
<tr>
<td>422</td>
<td>ACUTE MYOCARDITIS*</td>
<td></td>
</tr>
<tr>
<td>425</td>
<td>CARDIOMYOPATH*</td>
<td></td>
</tr>
<tr>
<td>425.0</td>
<td>ENDOMYOCARDIAL FIBROSIS</td>
<td></td>
</tr>
<tr>
<td>425.1</td>
<td>HYPERTR OBSTR CARDIOMYOP</td>
<td></td>
</tr>
<tr>
<td>425.2</td>
<td>OBSC AFRIC CARDIOMYOPATH</td>
<td></td>
</tr>
<tr>
<td>425.3</td>
<td>ENDOCARD FIBROELASTOSIS</td>
<td></td>
</tr>
<tr>
<td>425.4</td>
<td>PRIM CARDIOMYOPATH NEC</td>
<td></td>
</tr>
<tr>
<td>425.5</td>
<td>ALCOHOLIC CARDIOMYOPATH</td>
<td></td>
</tr>
<tr>
<td>425.7</td>
<td>METABOLIC CARDIOMYOPATH</td>
<td></td>
</tr>
<tr>
<td>425.8</td>
<td>CARDIOMYOPATH IN OTH DIS</td>
<td></td>
</tr>
<tr>
<td>425.9</td>
<td>SECOND CARDIOMYOPATH NOS</td>
<td></td>
</tr>
<tr>
<td>428</td>
<td>HEART FAILURE*</td>
<td></td>
</tr>
<tr>
<td>428.0</td>
<td>CHF NOS</td>
<td></td>
</tr>
<tr>
<td>428.1</td>
<td>LEFT HEART FAILURE</td>
<td></td>
</tr>
<tr>
<td>428.20</td>
<td>SYSTOLIC HRT FAILURE NOS</td>
<td></td>
</tr>
<tr>
<td>428.21</td>
<td>AC SYSTOLIC HRT FAILURE</td>
<td></td>
</tr>
<tr>
<td>428.22</td>
<td>CHR SYSTOLIC HRT FAILURE</td>
<td></td>
</tr>
<tr>
<td>ICD-9</td>
<td>Code</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>--------</td>
<td>------------------------------------</td>
</tr>
<tr>
<td>428.23</td>
<td></td>
<td>AC ON CHR SYST HRT FAIL</td>
</tr>
<tr>
<td>428.30</td>
<td></td>
<td>DIASTOLC HRT FAILURE NOS</td>
</tr>
<tr>
<td>428.31</td>
<td></td>
<td>AC DIASTOLIC HRT FAILURE</td>
</tr>
<tr>
<td>428.32</td>
<td></td>
<td>CHR DIASTOLIC HRT FAIL</td>
</tr>
<tr>
<td>428.33</td>
<td></td>
<td>AC ON CHR DIAST HRT FAIL</td>
</tr>
<tr>
<td>428.40</td>
<td></td>
<td>SYST/DIAST HRT FAIL</td>
</tr>
<tr>
<td>428.40</td>
<td></td>
<td>SYST/DIAST HRT FAIL NOS</td>
</tr>
<tr>
<td>428.41</td>
<td></td>
<td>AC SYST/DIASTOL HRT FAIL</td>
</tr>
<tr>
<td>428.42</td>
<td></td>
<td>CHR SYST/DIASTL HRT FAIL</td>
</tr>
<tr>
<td>428.43</td>
<td></td>
<td>AC/CHR SYST/DIA HRT FAIL</td>
</tr>
<tr>
<td>428.9</td>
<td></td>
<td>HEART FAILURE NOS</td>
</tr>
<tr>
<td>429.3</td>
<td></td>
<td>CARDIOMEGALY</td>
</tr>
<tr>
<td>429.4</td>
<td></td>
<td>HRT DIS POSTCARDIAC SURG</td>
</tr>
<tr>
<td>514</td>
<td></td>
<td>PULM CONGEST HYPOSTASIS</td>
</tr>
<tr>
<td>518.4</td>
<td></td>
<td>ACUTE LUNG EDEMA NOS</td>
</tr>
<tr>
<td>785.51</td>
<td></td>
<td>CARDIOGENIC SHOCK</td>
</tr>
<tr>
<td>786.0</td>
<td></td>
<td>DYSPNEA/RESPIRATORY ABN*</td>
</tr>
<tr>
<td>997.1</td>
<td></td>
<td>SURG COMPL-HEART</td>
</tr>
<tr>
<td>V42.1</td>
<td></td>
<td>HEART TRANSPLANT STATUS</td>
</tr>
<tr>
<td>109.9</td>
<td></td>
<td>RHEUMATIC HEART DIS, UNSPEC</td>
</tr>
<tr>
<td>ICD-10</td>
<td>Code</td>
<td>Description</td>
</tr>
<tr>
<td>-------</td>
<td>-------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>ICD-10</td>
<td>I11.0</td>
<td>HYPERTENS HRT DIS W/ HRT FAIL</td>
</tr>
<tr>
<td>ICD-10</td>
<td>I13.0</td>
<td>HYPERTENS HRT REN DIS W/ HF</td>
</tr>
<tr>
<td>ICD-10</td>
<td>I13.2</td>
<td>HYPERTENS HRT REN DIS W/ HF REN FAIL</td>
</tr>
<tr>
<td>ICD-10</td>
<td>I25.5</td>
<td>ISCHEM CARDIOMYOPATHY</td>
</tr>
<tr>
<td>ICD-10</td>
<td>I42.0</td>
<td>DILATED CARDIOMYOPATHY</td>
</tr>
<tr>
<td>ICD-10</td>
<td>I42.5</td>
<td>OTH RESTRICT CARDIOMYOPATHY</td>
</tr>
<tr>
<td>ICD-10</td>
<td>I42.6</td>
<td>ALCOHOLIC CARDIOMYOPATHY</td>
</tr>
<tr>
<td>ICD-10</td>
<td>I42.7</td>
<td>CARDIOMYOPATH DUE TO DRUGS/EXT CAUSES</td>
</tr>
<tr>
<td>ICD-10</td>
<td>I42.8</td>
<td>OTH CARDIOMYOPATHIES</td>
</tr>
<tr>
<td>ICD-10</td>
<td>I42.9</td>
<td>CARDIOMYOPATHY, UNSPEC</td>
</tr>
<tr>
<td>ICD-10</td>
<td>I43</td>
<td>CARDIOMYOPATH IN DIS CLASS ELSEWHERE</td>
</tr>
<tr>
<td>ICD-10</td>
<td>I43.0</td>
<td>CARDIOMYOPATH IN INFECT/PARASITIC DIS</td>
</tr>
<tr>
<td>ICD-10</td>
<td>I43.1</td>
<td>CARDIOMYOPATH IN METABOLIC DIS</td>
</tr>
<tr>
<td>ICD-10</td>
<td>I43.2</td>
<td>CARDIOMYOPATH IN NUTRITIONAL DIS</td>
</tr>
<tr>
<td>ICD-10</td>
<td>I43.8</td>
<td>CARDIOMYOPATH IN OTH DIS</td>
</tr>
<tr>
<td>ICD-10</td>
<td>I50</td>
<td>HEART FAILURE</td>
</tr>
<tr>
<td>ICD-10</td>
<td>I50.0</td>
<td>CONGESTIVE HEART FAILURE</td>
</tr>
<tr>
<td>ICD-10</td>
<td>I50.1</td>
<td>LEFT VENTRICULAR FAILURE</td>
</tr>
<tr>
<td>ICD-10</td>
<td>I50.9</td>
<td>HEART FAILURE, UNSPEC</td>
</tr>
<tr>
<td>ICD-10</td>
<td>P29.0</td>
<td>NEONATAL CARDIAC FAILURE</td>
</tr>
</tbody>
</table>