Validity and utility of ICD-10 administrative health data for identifying ST- and non ST-elevation Myocardial Infarction

Alka B Patel[1], PhD, Hude Quan[1], MD, PhD, Robert C Welsh[2], MD, Jessica Deckert-Sookram[2], MD, Wayne Tymchak[2], MD, Sunil Sookram[2], MD, Ian Surdhar[2], Padma Kaul[2*], PhD

[1]Department of Community Health Sciences, University of Calgary, Calgary, Canada

[2]Faculty of Medicine & Dentistry University of Alberta, Edmonton, Canada

[*]Corresponding author

Word count: 2360

Address for correspondence:

Padma Kaul, PhD

2-132 Li Ki Shing Centre

University of Alberta

Edmonton, Alberta, T6G 2E1

Phone: (780) 492-1140

Email: pkaul@ualberta.ca

Abstract (237)

Background: Healthcare administrative databases are extremely useful for assessing the population-level burden of disease and examining issues related to access, costs, and quality of care. In these databases, the diagnoses and procedures are coded using the World Health Organization (WHO) International Classification of Disease (ICD). We examined the validity of two ICD version 10 (ICD-10) coding definitions for categorizing acute myocardial infarction (AMI) patients as ST-elevation myocardial infarction (STEMI) or Non-ST-elevation myocardial infarction (NSTEMI).

Methods: Charts of AMI patients (April-June 2007) were reviewed to define the AMI subtype (i.e. STEMI and NSTEMI). The agreement between clinician chart review and STEMI/ NSTEMI classification based on: 1) the standard (ICD-10 I21.x); and 2) the supplementary electrocardiogram (ECG) codes (R94.3x) was determined. We assessed the impact of these alternative definitions on in-hospital mortality estimates by applying them to a cohort of all AMI patients from April 2007 – March 2010.

Results: Of 297 AMI patients, 49.3% were identified as STEMI based on chart review, 45.5% using the standard definition and 45.3% using the ECG definition. Both the standard and ECG definitions provided high agreement (92% for STEMI and 100% for NSTEMI) with the chart review classification. In the larger population-level cohort (n=15,148), using the standard definition or the ECG definition did not impact in-hospital mortality estimates for STEMI and NSTEMI patients.

Conclusions: The standard definition appears equivalent to the definition using supplementary ECG codes to subcategorize AMI patients as STEMI or NSTEMI.

Introduction

Healthcare administrative databases, such as those maintained by the Centers for Medicare and Medicaid Services (CMS) in the US and by provincial and federal agencies in Canada and other countries are extremely useful for assessing the population-level burden of disease and examining issues related to access, costs, and quality of care.[1-5] In these databases, the diagnoses and procedures are coded using the World Health Organization (WHO) International Classification of Disease (ICD).[6] With the exception of the US, all developed countries currently use version 10 of the ICD. The US is scheduled to switch from its current ICD-9-CM version to ICD-10 by October 2015. Because the WHO permits its member countries to add country-specific diagnosis codes or specify conditions using sub-codes in ICD-10, several countries have developed their own ICD-10 versions. [7]

The incidence and clinical characteristics of patients presenting with *ST-elevation* myocardial infarction (STEMI) and *non-ST-elevation* myocardial infarction (NSTEMI) vary significantly.[8, 9] These differences underline the importance of accurately classifying acute myocardial infarction (AMI) sub-types when examining patient outcomes. Historically, primarily due to limitations in coding algorithms, studies using administrative data to examine treatment and outcomes of AMI have grouped STEMI and NSTEMI together.[10, 11] However, the improved ICD-10 codes distinguish between STEMI and NSTEMI patients.[12] In April 2007, the Canadian version of ICD-10 introduced secondary diagnosis codes for cardiovascular function based on the electrocardiogram ECG.[13] Whether these supplementary codes are more accurate than the standard ICD-10 codes in differentiating between the AMI subtypes is not known.

The primary objective of our study was to evaluate the agreement of the standard definition (based on ICD-10 Q-wave codes alone) and the ECG definition (based on supplementary ECG codes) for classifying STEMI and NSTEMI with chart review by clinicians. We also applied both the standard and ECG definitions to a large in-patient AMI population and examined the extent to which in-hospital mortality estimates were affected by the use of the alternative definitions.

Methods

Defining STEMI and NSTEMI in Chart Data

All patients discharged from hospital with a diagnosis of AMI in Edmonton, Alberta Canada (population of approximately 1 million) undergo review by a trained chart abstractor. This is conducted as part of a dedicated quality assurance program linked to the Vital Heart Response (VHR) clinical program. VHR is a regional reperfusion program focused on delivering expeditious evidence based care for STEMI patients. To validate the chart abstraction process and confirm appropriate patient selection, charts from the three major hospitals in VHR were obtained. Patients with a diagnosis of AMI were independently abstracted to obtain an approximately equal sample of patients defined as STEMI and NSTEMI. Subsequently, two experienced clinicians reviewed the patients abstracted data, interpreted the 12-lead ECG and reviewed peak myocardial enzymes blindly determining clinical diagnosis of NSTEMI vs. STEMI (SS and WT). The AMI sub-type classification based on clinician chart reviews was used as the reference standard.

Defining STEMI and NSTEMI in Administrative Data

We used two definitions to categorize AMI patients as STEMI and NSTEMI. The *standard definition* was the presence of the following codes in the primary diagnosis field: ICD-10 codes I21.0-3 for STEMI and I21.4x for NSTEMI.

A patient presenting with an ECG indicative of STEMI can progress to a Q-wave MI, a non-Q wave MI or an aborted MI, while those with no ST-elevation on the ECG are defined as having NSTEMI and can only progress to a non-Q wave MI or unstable angina.[13] As a result, all patients that are coded with Q-wave MI (I21.0-3) should be STEMI, but some coded with non-Q wave MI (I21.4x) could also be STEMI. This shows why the supplementary ECG codes that can distinguish between ECG results suggestive of STEMI (R94.30) or NSTEMI (R94.31) could be useful in accurately categorizing patients into the two subtypes. [13] The ECG codes were introduced in April 2007 in Canada and therefore our validation study used the chart reviews of patients who were discharged from the three hospitals between April-June 2007. In our study, the *ECG definition* is the presence of ICD-10 code R94.30 in any diagnosis field for STEMI and ICD-10 code R94.31 in any diagnosis field for NSTEMI.

Analysis

The chart data were linked with hospital discharge abstract data (DAD) from April-June 2007 using the unique identifier of a personal health number (PHN). The DAD includes data on age, sex, length of stay, up to 25 diagnoses, 16 procedures, and discharge status. These linked DAD records were extracted using the date of admission and most responsible diagnosis of I21 (acute myocardial infarction). Those patients with invalid PHN were removed to create our final sample for the validation study.

We compared the agreement between the clinician chart review classification to the STEMI/NSTEMI classification based on the standard definition and the ECG definition. Those patients with an unspecified MI (I21.9) or an unspecified ECG result (R94.38) were excluded from the analysis. The agreement between chart review and the two sub-type definitions was calculated overall and by sex and age.

Utility of AMI sub-types in DAD

To determine the effects of sub-type definition when evaluating patient outcome, the standard and ECG definitions were applied to a dataset of all patients admitted to a hospital with AMI in Alberta, Canada between April 1, 2007 and March 31, 2010. This dataset contained information on age, sex, length of stay, diagnoses, procedural interventions and in-hospital mortality. Patients who had a primary diagnosis of I21.x were included in this assessment. A record of R94.3x (supplementary ECG code) in any of the secondary diagnosis fields was captured. The unit of analysis was the patient. To test the utility of the coding definitions, we calculated the in-hospital mortality proportion for STEMI and NSTEMI patients identified using the standard and ECG definition.

Data analysis was conducted using SAS version 9.2. The ethics board of the University of Alberta felt the study was for quality assurance purposes and did not require ethics approval.

Results

Linking chart and administrative data

Administrative data were linked with chart review data for 302 of 319 patients with a primary diagnosis of AMI (I21.x) between April 1, and June 30, 2007 (Figure 1). Once duplicate records and records with invalid PHN were removed, we had linked data for 297 patients. Seven patients were excluded as they were coded as 'Acute myocardial infarction, unspecified' using I21.9, and eight patients were excluded who were coded as R94.38, which does not specifically define the STEMI or NSTEMI sub-type or had missing or conflicting R94.3x coding.

The number of patients classified as STEMI and NSTEMI by chart review, standard definition, and ECG definition are presented in Table 1. For STEMI, the standard definition had a higher agreement with chart review overall (92.3%) than the agreement between the ECG definition and chart review (91.6%). The higher agreement between standard definition and chart review relative to the agreement between ECG definition and chart review remained among males and among both young (age $<$ 65 years) and elderly (age $\geq$ 65 years). However, the agreement statistic for both definitions was lower for elderly patients compared with younger patients. In contrast to males, the ECG definition for STEMI had a higher level of agreement with chart review among women (89.1%) compared with standard definition (87%).

The agreement between both the standard definition and the ECG definition for NSTEMI was perfect, i.e., all patients identified by chart review as being NSTEMI were classified as NSTEMI by both definitions. There were, however, STEMI patients who were categorized as NSTEMI patients in our study. The level of misclassification was as follows: based on the standard definition, 7.7% of STEMI patients were classified as NSTEMI and 0% NSTEMI patients were classified as STEMI; based on the ECG definition, 8.4% of STEMI were classified as NSTEMI and 0% NSTEMI were classified as STEMI.

Utility of AMI sub-type codes

We applied the standard and ECG coding definitions for STEMI and NSTEMI to a larger sample of 15,148 patients hospitalized with a primary diagnosis of AMI (I21.x) between April 1, 2007 and March 31, 2010. Among these patients, 5713 were diagnosed as STEMI (37.7%) and 9435 patients as NSTEMI (62.3%) based on the standard definition. There were 528 patients with either an unspecified abnormal ECG result (R94.38) or with missing supplementary R94.3x code (3.5%), and 20 patients had both the R94.30 and R94.31 codes (0.1%). When only the ECG definition was used to define the AMI sub-types, 5530 (36.5%) were classified as STEMI and 9070 (59.9%) were classified as NSTEMI. Table 2 summarizes these findings and shows that the calculation of in-hospital mortality is similar irrespective of which definition was employed.

Discussion

Our study examining the validity of two definitions, one using standard ICD-10 codes and the second using supplementary ECG codes, for categorizing AMI patients as STEMI or NSTEMI has several novel and interesting findings. First, we found that both definitions were good at differentiating between STEMI and NSTEMI for a sample of confirmed AMI patients. The agreement between both definitions and clinician chart review was high across all patient subgroups with the exception of the coding of STEMI for patients older than 65 years, where the agreement was slightly lower. Second, for STEMI, the standard definition had a slightly higher agreement with chart review (92.3%) than the agreement between the ECG definition and chart review (91.6%). Third, the agreement between both the standard definition and the ECG definition for NSTEMI was perfect, i.e., all patients identified by either definition as being NSTEMI were classified as NSTEMI by chart review. And finally, when we applied the two definitions to a database of AMI hospitalizations, we found that the different methods of classifying AMI sub-types did not affect in-hospital mortality estimates.

The STEMI and NSTEMI sub-type coding validation relies on the validation of AMI first. Studies have shown that AMI is coded well using ICD. A recent systematic review has reported that there have been several studies validating the case definitions for AMI, with most studies focused on ICD-9 and no studies validating exclusively ICD-10 codes.[14] The validity of these diagnosis codes for identifying AMI has varied in the literature from a sensitivity of 66% to 95.1% and a specificity of 80.2 to 100% depending on the subgroup, database and area studied.[14] Although this systematic review revealed that there have been no studies conducted that validate the AMI sub-types as defined using recently revised ICD coding definitions, ICD-9CM codes for AMI patients have been used to differentiate between STEMI and NSTEMI patients[15] and more recently ICD-10 codes have been used for this purpose.[12]

Studies have been conducted evaluating the validity of ICD-9 coding for AMI. In one Canadian province, Saskatchewan, a study using data from November 1999 – December 2001 found that ICD-9 codes for AMI had a PPV of 0.95 (95%CI: 0.91–0.98) for identifying those patients with AMI based on detailed chart review as the gold standard[16]. While many studies validating the case definitions of AMI using ICD coding have shown similar high positive predictive value or sensitivity [17], they have not distinguished the validity of AMI sub-types using ICD coded data.

There have been studies conducted in the United States validating the AMI sub-type coding definitions for ICD-9CM. Using the current ICD-9CM coding definitions, NSTEMI patients are those with a diagnosis code of 410.7, while those patients with codes 410-410.8 are classified as STEMI patients[18]. One US study with a very large sample size (over 1 million) found that 10.9% of patients who were found to have STEMI based on an ECG were coded as 410.71, while 38.8% of patients with ECG indicative of NSTEMI had an ICD-9 code other than 410.71[19]. Our study shows that the Canadian ICD-10 codes were less likely to misclassify both STEMI and NSTEMI than has previously been reported using ICD-9CM.

Using data from the 2000-2001 fiscal years, researchers found that MI as recorded in medical charts was incomplete and inconsistent in its ability to distinguish between STEMI and NSTEMI and that up to 20% of medical records could not be used for retrospective MI sub-type specific research[20]. The inconsistencies in the medical record review are one possible reason for the misclassification of coded information. If the information in the charts is not recorded completely, then it is not possible for coders to transfer this information to the administrative data codes that could then be used to distinguish between AMI sub-types. When we applied the sub-type coding definitions in our study we found that approximately 0.13% of patients in our sample were inconsistently coded with codes that included an R94.3x code representing one sub-type with an R94.3x code of a different sub-type. One could speculate that the lower agreement for the coding of STEMI for adults older than 65 years could be due to physician documentation being less for seniors with multiple conditions than younger patients. It is also possible that coders spend less time on senior's records when there are large amounts of information on conditions.

There are limitations to this study that should be considered when interpreting the results. It is important to note that this study does not provide any information on the validity of AMI coding. Instead it only examines the validity of sub-categorizing AMI patients into STEMI and NSTEMI patients. Therefore, given that our study only includes AMI patients, we are unable to provide the positive predictive value, negative predictive value, sensitivity or specificity associated with the AMI diagnosis. The reference standard for this study was a convenience sample of chart reviews conducted over a three-month period for patients who presented to three hospitals in one Canadian city. To ensure the generalizability of these study findings it would be valuable to conduct this type of validation study over different regions of the country as well as internationally for the ICD-10

AMI sub-type coding distinctions. Although this study was limited to a smaller study area, it covered a range of hospital settings in a large urban center.

Conclusions

Among AMI patients, the standard ICD-10 definition to classify patients as STEMI or NSTEMI is as accurate as the supplementary definition based on ECG codes. Our study demonstrates that the AMI subtype codes are valid and can be used in population-based outcome studies.

Acknowledgements

None

Funding Sources

During the course of the study, Drs Patel, Quan and Kaul were supported by Alberta Innovates Health Solutions (AIHS) Doctoral Studentship, Health Scholar, and Population Health Investigator awards, respectively.

Disclosures

None

References

1. Colonna M, Mitton N, Schott A-M, Remontet L, Olive F, Gomez F, Iwaz J, Polazzi S, Bossard N, Trombert B. Joint use of epidemiological and hospital medico-administrative data to estimate prevalence. Application to french data on breast cancer. *Cancer epidemiol*. 2012;36:116-121

2. Garland A, Yogendran M, Olafson K, Scales DC, McGowan K-L, Fransoo R. The accuracy of administrative data for identifying the presence and timing of admission to intensive care units in a canadian province. *Medical Care*. 2012;50:e1-6

3. Haley VB, Van Antwerpen C, Tserenpuntsag B, Gase KA, Hazamy P, Doughty D, Tsivitis M, Stricof RL. Use of administrative data in efficient auditing of hospital-acquired surgical site infections, new york state 2009-2010. *Infect Control Hosp Epidemiol*. 2012;33:565-571

4. Manuel DG, Lam K, Maaten S, Klein-Geltink J. Using administrative data to measure the extent to which practitioners work together: "Interconnected" care is common in a large cohort of family physicians. *Open Med*. 2011;5:e177-182

5. Meenan RT, Goodman MJ, Fishman PA, Hornbrook MC, O'Keeffe-Rosetti MC, Bachman DJ. Pooling multisite administrative data for economic analysis. *Expert rev*. 2002;2:477-483

6. WHO. International classification of diseases (icd). 2009

7. Jetté N, Quan H, Hemmelgarn B, Drosler S, Maass C, Moskal L, Paoin W, Sundararajan V, Gao S, Jakob R, Üstün B, Ghali WA, Investigators ftI. The development, evolution, and modifications of icd-10: Challenges to the international comparability of morbidity data. *Medical Care*. 2010;48:1105-1110 1110.1097/MLR.1100b1013e3181ef1109d1103e

8. McManus DD, Gore J, Yarzebski J, Spencer F, Lessard D, Goldberg RJ. Recent trends in the incidence, treatment, and outcomes of patients with stemi and nstemi. *American Journal of Medicine*. 2011;124:40-47

9. Montalescot G, Dallongeville J, Van Belle E, Rouanet S, Baulac C, Degrandsart A, Vicaut E, for the OI. Stemi and nstemi: Are they so different? 1 year outcomes in acute myocardial infarction as defined by the esc/acc definition (the opera registry). *European Heart Journal*. 2007;28:1409-1417

10. Weiss ES, Chang DD, Joyce DL, Nwakanma LU, Yuh DD. Optimal timing of coronary artery bypass after acute myocardial infarction: A review of california discharge data. *J Thorac Cardiovasc Surg*. 2008;135:503-511, 511.e501-503

11. Tu JV, Austin PC, Chan BTB. Relationship between annual volume of patients treated by admitting physician and mortality after acute myocardial infarction. *Jama-Journal Of The American Medical Association*. 2001;285:3116-3122

12. Patel AB, Quan H, Faris P, Knudtson ML, Traboulsi M, Li B, Ghali WA. Temporal associations of early patient transfers and mortality with the implementation of a regional myocardial infarction care model. *Canadian Journal of Cardiology*. 2011;27:731-738

13. Canadian Institute of Health Information. Canadian coding standards for version 2012 icd-10-ca and cci. *Appendix A—Acute Coronary Syndrome (ACS) and Related Interventions*. 2012

14. Metcalfe A, Neudam A, Forde S, Liu M, Drosler S, Quan H, Jetté N. Case definitions for acute myocardial infarction in administrative databases and their impact on in-hospital mortality rates. *Health Services Research*. 2012:n/a-n/a

15. Zhang Z, Fang J, Gillespie C, Wang G, Hong Y, Yoon PW. Age-specific gender differences in in-hospital mortality by type of acute myocardial infarction. *American Journal of Cardiology*. 2012;109:1097-1103

16. Varas-Lorenzo C, Castellsague J, Stang MR, Tomas L, Aguado J, Perez-Gutthann S. Positive predictive value of icd-9 codes 410 and 411 in the identification of cases of acute coronary syndromes in the saskatchewan hospital automated database. *Pharmacoepidemiology & Drug Safety*. 2008;17:842-852

17. Metcalfe A. Case definitions for defining acute myocardial infarction in administrative databases: A systematic review and the impact of validated case definitions on in-hospital mortality rate. 2012

18. Cannon CP. Update to international classification of diseases, 9th revision codes: Distinguishes stemi from nstemi. *Critical Pathways in Cardiology: A Journal of Evidence-Based Medicine*. 2005;4:185-186

19. Steinberg BA, French WJ, Peterson ED, Frederick PD, Cannon CP, National Registry of Myocardial Infarction I. Missed diagnosis of the diagnosis codes: Comparison of international classification of diseases, 9th revision coding and st- versus non-st-elevation myocardial infarction diagnosis in the national registry of myocardial infarction. *Critical Pathways in Cardiology: A Journal of Evidence-Based Medicine*. 2006;5:59-63

20. Woo KS, Ghali WA, Southern DA, Tu JV, Parsons G, Graham MM. Feasibility of determining myocardial infarction type from medical record review. *Canadian Journal of Cardiology*. 2008;24:115-117

Figure Legend

Figure 1: Steps to defining a study sample for validating AMI sub-type coding

AMI indicates acute myocardial infarction; ECG, electrocardiogram; PHN, personal health number; NSTEMI, non-ST-elevation myocardial infarction; STEMI, ST-elevation myocardial infarction

Table 1. Evaluating the validity of ICD-10-CA coding for AMI sub-types among AMI patients

Patients	Chart Review		Standard Definition*				ECG Definition**			
	N		N		Agreement %		N		Agreement %	
	STEMI	NSTEMI	STEMI	NSTEMI	STEMI	NSTEMI	STEMI	NSTEMI	STEMI	NSTEMI
Overall	143	147	132	158	92.31	100	131	158	91.61	100
Female	46	55	40	61	86.96	100	41	60	89.13	100
Male	97	92	92	97	94.85	100	90	98	92.78	100
Age < 65 years	82	67	81	70	98.78	100	79	69	96.34	100
Age >= 65 years	61	80	51	88	83.61	100	52	89	85.25	100

* I21.0-3 for STEMI vs. I21.4x for NSTEMI. N=290.

** R94.30 (“ECG suggestive of STEMI”) vs. R94.31 (“ECG suggestive of NSTEMI”). N=289 because chart Review for ECG definition is missing one male under 65 years of age

Table 2. Application of coding definitions to in-patient data

Group	AMI type	Coding Definition	Mortality (%)	Number of Patients
Overall				
Standard definition	STEMI	I21.0,1, 2 or 3	5.51	5713
	NSTEMI	I21.4x	3.95	9435
ECG definition	STEMI	R94.30	5.42	5530
	NSTEMI	R94.31	3.89	9070
Female				
Standard definition	STEMI	I21.0,1, 2 or 3	8.79	5713
	NSTEMI	I21.4x	4.82	9435
ECG definition	STEMI	R94.30	8.63	5530
	NSTEMI	R94.31	4.77	9070
Male				
Standard definition	STEMI	I21.0,1, 2 or 3	4.32	5713
	NSTEMI	I21.4x	3.51	9435
ECG definition	STEMI	R94.30	4.28	5530
	NSTEMI	R94.31	3.45	9070
Age < 65 years				
Standard definition	STEMI	I21.0,1, 2 or 3	2.15	5713
	NSTEMI	I21.4x	0.62	9435
ECG definition	STEMI	R94.30	2.2	5530
	NSTEMI	R94.31	0.57	9070
Age >= 65 years				
Standard definition	STEMI	I21.0,1, 2 or 3	10.25	5713
	NSTEMI	I21.4x	6.41	9435
ECG definition	STEMI	R94.30	10.07	5530
	NSTEMI	R94.31	6.36	9070

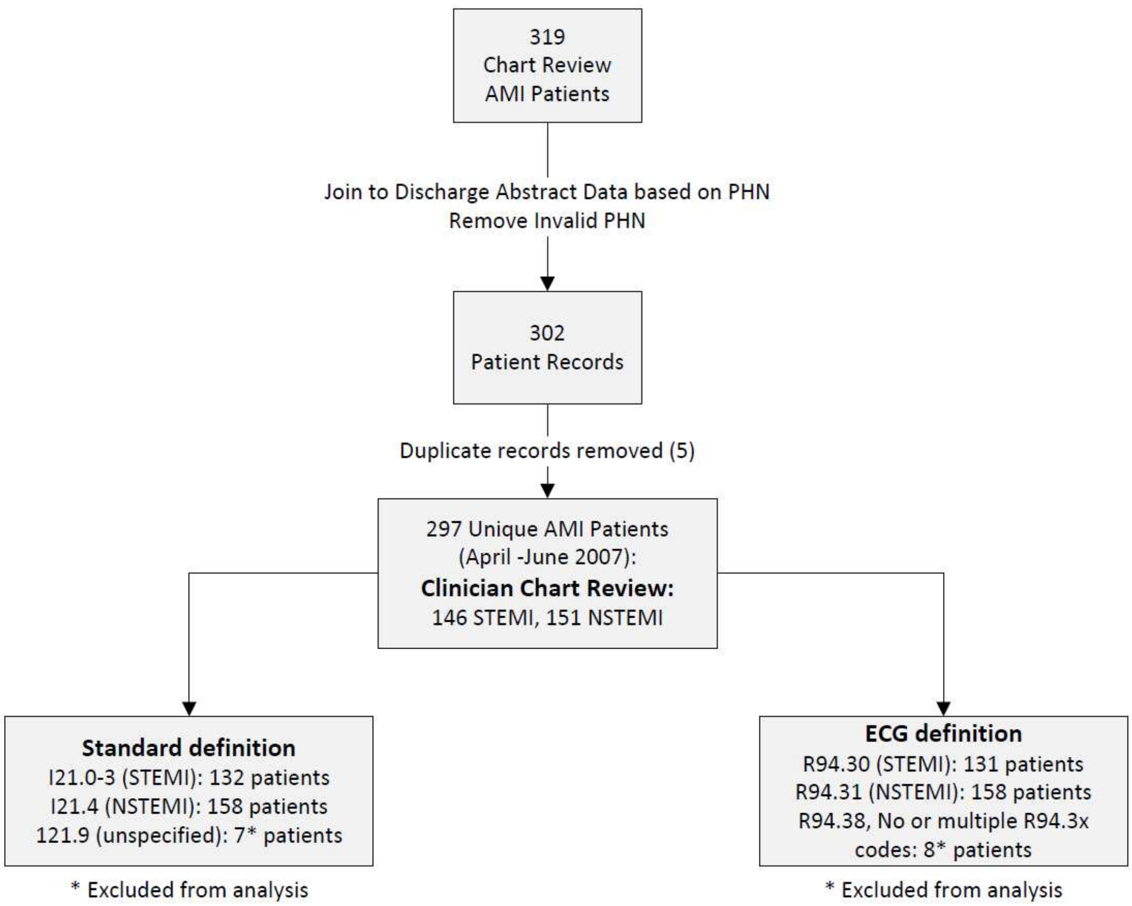

Figure 1. Steps to defining a study sample for validating AMI sub-type coding