**ARIC Manuscript Proposal #1996**

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| **PC Reviewed: 9/11/12** | **Status: A** | **Priority: 2** |
| **SC Reviewed: _____** | **Status: _____** | **Priority: ____** |

**1.a. Full Title**: Estimated burden of acute decompensated heart failure hospitalization in the United States: Applying model from the ARIC study to National Databases

**b. Abbreviated Title: National burden of ADHF hospitalization**

**2. Writing Group (alphabetically)**:
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**Others welcome**

I, the first author, confirm that all the coauthors have given their approval for this manuscript proposal. _SKA_ **[please confirm with your initials electronically or in writing]**

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**3. Timeline**:
Analysis to begin immediately. Plan for manuscript within 9 months

**4. Rationale**:
Heart Failure (HF) is estimated to affect about 6.6 million North Americans and contributes to a sizeable economic burden with hospitalizations alone contributing to 3% of "national hospital bill"[1]. It remains one of the most common hospital discharge diagnosis in the US with ~ 1.1 million hospitalizations with HF as primary discharge code (428.x). he recently published AHA report notes that "Hospital discharges for HF were essentially unchanged from 1999 to 2009" estimated around a million.[1] However,

a simple query to Agency of Healthcare Research and Quality (AHRQ) database shows that any mention of HF has gone up from 3.3 million to 5.9 million in the same time period[2]. In 2010, HF International Classification of Diseases (ICD) code at non-primary position occurred at more than 5 times than the primary position[2]. ICD code at non-primary position could signify either historical/chronic heart failure or true acute decompensated heart failure (ADHF). The second i.e., ADHF with non-primary HF discharge code may be understood in the light of clinical observations that HF patients may present with comorbidities that may have even lead to the decompensation itself such as myocardial ischemia, COPD exacerbation, atrial fibrillation, hypertensive emergency, renal failure etc.

It is important to estimate the burden of ADHF i.e., HF patients that required escalation of treatment of HF to relieve symptoms or prevent death during the admission. Understanding trends in the burden of ADHF will help monitor quality and outcomes of heart failure care and prevention of recurrent hospitalizations. Because of poor reliability of ICD code in primary position to capture ADHF, there is a need to develop a model that allows recalibration of national hospitalization ICD code estimates to validated ADHF. In this context, the ARIC surveillance has reported that hospitalizations with HF ICD code as any position has a sensitivity, specificity, and positive predictive value of 95%, 17% and 62% as compared to 43%, 95%, and 93% when using primary code only[3]. The above proportions will be different if one included chronic stable heart failure.

The ARIC surveillance provides an unique opportunity to derive models to identify ADHF using ICD codes, socio-demographics, hospital characteristics, payer characteristics, costs, and length of stay in a large population based sample (bi-racial, multiple/location - geographically diverse). Such a model will be applied to National Inpatient Sample database by AHRQ to allow recalibration to estimate the national burden of ADHF. (Comment: Why use NIS instead of NHDS? We may need to address this either in the proposal or final paper. For your reference, here is a report from a comparison study: http://www.ahrq.gov/data/hcup/nhds/niscomp.htm)

**5. Main Hypothesis/Study Questions**:

1. The burden of ADHF hospitalizations in the US is much higher than estimates using heart failure as the primary discharge code.
2. ADHF hospitalization rates have increased over the past decade in contrast to the flat estimates for hospitalizations with heart failure as the primary discharge code.

To test above hypotheses, we will derive models to identify ADHF using ICD codes as well as other variables available in both the national databases as well as the ARIC HF surveillance database, such as socio-demographics, hospital characteristics, ICD codes for comorbidities etc. We will examine the variability of such models by race, hospital type, US region, year of surveillance etc. to understand the coding differences by such characteristics. If we are able to find a reasonable model that provides accuracy of at-least 75%, we will apply it to the recent NIS database to estimate the national burden of

ADHF. We will report the length of stay, costs and other characteristics of those with model-based ADHF and contrast this with those with HF code but no ADHF, and no HF group.

**6. Design and analysis (study design, inclusion/exclusion, outcome and other variables of interest with specific reference to the time of their collection, summary of data analysis, and any anticipated methodological limitations or challenges if present).**

This study will use all ARIC HF surveillance hospitalizations with presence of HF code (ICD 428.x) at any position. The reason to use 428.x only is that the national estimates are mostly based (>90% of cases) to keep the universe of derivation and application similar. We will use logistic regression and standard prediction model statistics of discrimination and calibration to develop and evaluate models which allow predicting or identifying ADHF based on data elements collected in ARIC and also available in the NIS. These models will expand the useful initial two by two tables which showed that HF ICD code as any position has a sensitivity, specificity, and positive predictive value of 95%, 17% and 62% as compared to 43%, 95%, and 93% when using primary code only[3]. For those who were not abstracted (skipped) due to non-fulfillment of at-least one of the six screenings question and has an ICD code of 428.x, we will regard them as no HF by ARIC study panel.

The outcome modeled will be ADHF as adjudicated by the ARIC physician panel. The most important variable will be presence of a HF ICD code (428.x or I-50) and its position (first, second, etc.). We will test how position relates to prediction of ADHF, e.g. is it sufficient to model first vs. other or do we need more detail. The variables used will include patient level information such as socio-demographics (age, sex, race), ICD codes for comorbidities (categorized and noted for position as first vs. other); patient care related information such as procedures done (categorizing the most informative ADHF related procedures such as echocardiogram, chest x-ray, central line placement, device placement, angiography etc.), length of stay, mortality. We will also explore the importance of race, hospital type, and calendar year in influencing the model.

We will have limited information to explore the influence of health care system related information such as US region of hospital, hospital type (teaching vs. non-teaching), payer etc. We do understand that the model based approach is to achieve higher specificity without sacrificing sensitivity greatly; we will use ROC plots to find out the risk score for most accurately defining ADHF. We also appreciate that face validity of the model; particularly in terms of robustness to generalizing to a national sample will be important.

The NIS samples 20% hospitalizations in the US hospitalizations with most recent sample (2010) has information collected from 45 States, 1051 hospitals across U.S. Similarly, National Hospital Discharge Survey (NHDS) similarly is a probability sample

of inpatients discharged from non-Federal short-stay hospitals with a sample of about 2.7 million records annually from about 500 hospitals in the US.
For aim 1, after deriving a model with good characteristics and cut-point of risk profile score for ADHF, we will apply it to the NIS 2000, 2005, and 2010.
For aim 2, we will use NIS trend file from 1990 through 2010 and apply the accuracy proportion achieved for 2010 dataset. We will compare the proportion in year 2000 and 2005 from direct derivation based on model vs. application of average correction from model applied to year 2010. Similarly, sensitivity analysis using NHDS data will be performed. We will report a range of burden with estimates based on variability induced by different cut-points on ROC curves, different models (based on susceptibility to variation by race, year of data collected etc).

Additionally we will use "Trialist" HF classification, which requires less resources than adjudication panel, to define ADHF and report the burden as above.

**7.a. Will the data be used for non-CVD analysis in this manuscript? No**

**8.a. Will the DNA data be used in this manuscript? No**

**9.The lead author of this manuscript proposal has reviewed the list of existing ARIC Study manuscript proposals and has found no overlap between this proposal and previously approved manuscript proposals either published or still in active status. Yes**

**10. What are the most related manuscript proposals in ARIC (authors are encouraged to contact lead authors of these proposals for comments on the new proposal or collaboration)?**

Ms. # 1829: Trends in hospitalizations for myocardial infarction and heart failure: A comparison of national, community, and cohort data (1987-2008) – (this compares secular trend in projected # of hospitalizations through years using a combination of ARIC cohort, surveillance, and national hospital discharge database and the difference in such rates.)

**11. Is this manuscript proposal associated with any ARIC ancillary studies or use any ancillary study data? No**

**12. Manuscript preparation is expected to be completed in one to three years. If a manuscript is not submitted for ARIC review at the end of the 3-years from the date of the approval, the manuscript proposal will expire.**


1. Roger, V.L., et al., *Heart disease and stroke statistics--2012 update: a report from the American Heart Association.* Circulation, 2012. **125**(1): p. e2-e220.
2. *Hospital discharges with heart failure code at any position: National Inpatient Sample 1993 through 2010*. [cited 2012; Available from: http://hcupnet.ahrq.gov/.
3. Rosamond, W.D., et al., *Classification of heart failure in the atherosclerosis risk in communities (ARIC) study: a comparison of diagnostic criteria.* Circ Heart Fail, 2012. **5**(2): p. 152-9.