Web Material

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WEB TABLES

Web Table 1. Description of eligible ICD codes used to sample potential Heart Failure hospitalizations in the ARIC HF surveillance

ICD Code	Disease Classification
398.91	Rheumatic heart disease
402.01	Hypertensive heart disease-malignant with CHF
402.11	Hypertensive heart disease-benign with CHF
402.91	Unspecified hypertensive heart disease with CHF
404.01	Hypertensive heart disease and renal failure-malignant with CHF
404.03	Hypertensive heart disease and renal failure-malignant with congestive heart and renal failure
404.11	Hypertensive heart disease and renal failure-benign with CHF
404.13	Hypertensive heart disease and renal failure-benign with congestive heart and renal failure
404.91	Hypertensive heart disease and renal failure-unspecified with CHF
404.93	Hypertensive heart disease and renal failure-unspecified with congestive heart and renal failure
415	Acute cor pulmonale
416.9	Chronic pulmonary heart disease, unspecified
425.4	Other primary cardiomyopathies
428.x	CHF
518.4	Acute edema of lung, unspecified abnormalities
786.0x	Dyspnea and respiratory

CHF, congestive heart failure; ICD-9-CM, *International Classification of Diseases, Ninth Revision, Clinical Modification*.

The same codes were used in both the Atherosclerosis Risk in Community Study surveillance and the National Inpatient Sample.

Web Table 2. Description of ICD codes used to define comorbidities in both ARIC heart failure surveillance and the National Inpatient Sample database	
Heart valve disorder	424.0, 424.1, 424.2, 424.3, 424.90, 424.91, 424.99, 785.2, 785.3, V42.2 V43.3
Atrial fibrillation/atrial flutter	427.31, 427.32
Cardiac dysrhythmias (not AF or atrial flutter)	427.0, 427.1, 427.2, 427.9, 427.60, 427.41, 427.42, 427.5, 427.61, 427.69, 427.81, 427.89, 427.9, 785.0, 785.1
Conduction disorder	426.0, 426.10, 426.11, 426.12, 426.13, 426.2, 426.3, 426.4, 426.50, 426.51, 426.52, 426.53, 426.54, 426.6, 426.7, 426.81, 426.82, 426.89, 426.9, V45.0, V45.00 V45.01, V45.02, V45.09, V53.3, V53.31, V53.32, V53.39
Acute myocardial infarction	410.xx
Coronary atherosclerosis or other heart disease	411.0, 411.1, 411.8, 411.81, 411.89, 412 413.0, 413.1, 413.9, 414.0, 414.00, 414.01, 414.06, 414.2, 414.3, 414.4, 414.8, 414.9, V458.1, V458.2
Chronic kidney disease	585.0, 585.1, 585.2, 585.3, 585.4, 585.5, 585.6, 585.9, 792.5, V42.0, V45.1, V45.11, V45.12, V56.0, V56.1, V56.2, V56.31, V56.32, V56.8
Acute kidney injury	584.5, 584.6, 584.7, 584.8, 584.9, 586
COPD exacerbation	491.21, 491.22, 494.1
Pneumonia	480.x, 481.x, 482.x, 483.x, 484.x, 485.x, 486.x
Other fluid and electrolyte disorders	276.0, 276.2, 276.3, 276.4, 276.6, 276.69, 276.9, 995.1
Anemia	285.21, 285.29, 285.9
Hypertension	401.x

AF, atrial fibrillation; COPD, chronic obstructive pulmonary disease; ICD-9-CM, *International Classification of Diseases, Ninth Revision, Clinical Modification*.

The same codes were used in both the Atherosclerosis Risk in Community Study surveillance and the National Inpatient Sample. The codes are similar to those suggested by National Inpatient Sample clinical classification software.

Web Table 3. Prevalence and corresponding positive predictive value (ADHF) for study characteristics by 428 groups in the ARIC ADHF surveillance

	428 Primary (*n* = 2083)		**428 Nonprimary (*n* = 6936)**		**428 Absent (*n* = 3431)**	
	%	**PPV**	**%**	**PPV**	**%**	**PPV**
Eligible codes						
428 in primary position	100	90			0	
428 in second position	0		28	38	0	
428 in position 3–26	0		72	30	0	
428 absent	0		0		100	16
Rheumatic HF	0		0	80	6	68
Hypertensive HF	1	95	4	55	0	56
Renal HF	1	89	4	59	1	58
Pulmonary HF	1	100	1	52	5	20
Cardiomyopathy	17	92	11	44	42	12
Pulmonary edema	0	100	0	76	4	61
Respiratory distress	3	93	3	48	41	8
Comorbid conditions	0		0		0	
Atrial fibrillation	37	93	35	38	26	21
Cardiac dysrhythmia	16	92	16	40	18	16
Conduction disorder	11	91	10	44	9	18
Myocardial infarction	4	97	8	61	4	37
COPD	9	86	12	44	8	14
Other characteristics	0		0		0	
Race	0		0		0	
Caucasian	57	90	60	32	64	14
NonCaucasian	43		38		32	
Sex	0		0		0	
Female	49	89	52	31	46	17
Male	51	91	47	34	51	16
Teaching hospital status	0		0		0	
Teaching	33	92	38	32	30	19
Nonteaching	66	89	61	31	68	15
Age group, years	0		0		0	
55-64	22	90	22	32	29	16
65-74	25	89	26	31	28	14
≥75	51	90	53	32	43	18

ARIC HF surveillance of potential HF hospitalizations in four US communities (age ≥55 years at discharge). % is column percent. HF, heart failure; PPV, positive predictive value [for ADHF].

WEB APPENDIX

1. Derivation of model to predict ADHF probability from the ARIC HF surveillance

Additional details regarding derivation of the validation models as well as additional results from model-building are provided here.

Models were developed separately for the three ICD code 428 code groups: 428 primary, nonprimary, and absent (non428 eligible ICD codes). We used a structured approach to build multivariate logistic regression models to predict the probability of ADHF. All models included age, race, sex, and teaching hospital status. We collapsed certain groups of HF codes defining conceptually similar and low prevalent conditions such as hypertensive heart failure, hypertensive-renal heart failure, rheumatic heart failure, pulmonary heart failure etc. into an 'other heart failure group'. We then identified comorbidities that are common in patients with heart failure (coronary atherosclerosis, chronic kidney disease, electrolyte imbalance-hyponatremia), those that may precipitate ADHF (atrial fibrillation, acute myocardial infarction), or may represent a treatment complication (acute kidney injury) and considered those with > 5% prevalence in at least one of the three ICD code 428 groups.

Model selection was conducted to achieve adequate model fit, discrimination and calibration while minimizing model complexity to avoid over-fitting. Variables defining presence of HF codes, position of the 428 code (second position vs. 3-26 included in the ICD code 428 nonprimary group only) and comorbidity codes were selected using a forward stepwise procedure (Wald test P value < 0.20) and then eliminated in a stepwise fashion until measures of model fit, discrimination and calibration (Hosmer-Lemeshow, AUC and Integrated discrimination improvement [IDI], respectively) were impacted. See Supplementary Tables 5a-c for a summary of the results. In these reduced models, we replaced comorbidity in any position variables with two code position variables (primary vs. nonprimary) to test the significance of code position. Position variables were kept only if both were significant (Wald P value < 0.20); otherwise the presence variable was maintained in the model. We also examined Arjas plots to assess final model fit (Supplementary Figure 2).

To assess internal validity of the final models, we examined AUC and calibration slope corrected for optimism (1000 bootstrap samples).[12,13]. We fitted models with interaction terms and examined Arjas plots in subgroups to assess consistency of model fit across ARIC community and study year.

Final models with optimism-corrected statistics are presented in Supplementary Tables 6a-c, ROC curves are presented in Supplementary Figure 1 and Arjas plots are presented in Supplementary Figures 2-4.

2. Variance of the Estimator of ADHF Hospitalizations Count and Rate

We applied the ADHF validation models derived in ARIC to NIS data to estimate the total number of ADHF hospitalizations. Population estimates were then used to calculate rates. The count estimator and derivation of the variance of the count estimator are presented here as well as the variance of the rate estimator.

The count estimator is composed of the sum of validation model-based predicted probabilities restricted to the domain defined by inclusion criteria described in Figure 1, summed over NIS strata, sampled hospitals within strata and hospitalizations within sampled hospitals. The validation model applied differs by ICD code 428 code group (primary, nonprimary, absent).

The set of NIS strata is $A = \{1,\ldots,a\ldots,N_A\}$, the set of hospitals in stratum a is $U_{aI} = \{1,\ldots,i,\ldots,N_{aI}\}$ and the set of hospitalizations in stratum a, hospital i is $H_{ai} = \{1,\ldots,k,\ldots N_{aiH}\}$. The inclusion probability for hospital i from stratum a is π_{ai} and the set of sampled hospitals is S_a.

The estimator of the number of ADHF hospitalizations for domain D is therefore given in Equation (1).

$$\hat{T}_D = \sum_{a=1}^{N_A} \sum_{i=1}^{N_{aI}} \sum_{k=1}^{N_{aiH}} \pi_{ai}^{-1}\, I(i \in S_a)\; I(k \in D)\, \text{logit}^{-1}\big(x_{aik}\hat{\beta}_c\,\big|c, x_{aik}\big) \qquad (1)$$

where D is the domain satisfying inclusion criteria described in Figure 1. NIS data and logistic regression coefficient estimates from the ARIC validation model used to calculate predicted probabilities are represented by the vectors x_{aik} and $\hat{\beta}_c$, respectively. ICD code 428 code group is represented by c. $I(z)$ is an indicator variable taking on the value 1 when z is true, 0 otherwise.

The variance of the estimate in (1) is therefore given by (2):

$$\text{Var}\big(\hat{T}_D\big) = \text{E}\{\text{Var}\big(\hat{T}_D\,|\hat{\beta}\,\big) + \text{Var}\{\text{E}\big(\hat{T}_D\,|\hat{\beta}\,\big)\} \qquad (2)$$

Since $\hat{\beta}$ is an unbiased estimate, $\text{E}\big\{\text{Var}\big(\hat{T}_D\,\big|\hat{\beta}\big)\big\} = \text{Var}\big(\hat{T}_D\,\big|\beta\,\big)$.

To calculate $\text{Var}\big(\hat{T}_D\,\big|\beta\,\big)$, let the number of estimated ADHF hospitalizations for domain D in hospital I and stratum a, be represented by t_{aiD} defined in (3).

$$t_{aiD} = \sum_{k=1}^{N_{aiH}} I(k \in D)\, \text{logit}^{-1}(x_{aik}\beta_c\,|c, x_{aik}) \qquad (3)$$

Then the variance of $\hat{T}_D$ given β is defined in (4).

$$\operatorname{Var}\left(\hat{T}_D \,\middle|\beta\right) = \sum_{a=1}^{A}\sum_{i=1}^{N_{aI}}\sum_{j=1}^{N_{aI}} \frac{\pi_{aij} - \pi_{ai}\pi_{ai}}{\pi_{aij}} \frac{t_{aiD}}{\pi_{ai}} \frac{t_{ajD}}{\pi_{aj}} \qquad (4)$$

where π_{aij} = Pr(hospital *i* and hospital *j* in stratum *a* are both selected).

Denote $\tilde{t}_{aiD}$ as $\sum_{k=1}^{N_{aiH}} I(k \in D) \operatorname{logit}^{-1}\left(x_{aik}\hat{\beta}_{y_k} \,\middle|y_k, x_{aik}\right)$, and

$$\widehat{\operatorname{Var}}\left(\hat{T}_D \,\middle|\beta\right) = \sum_{a=1}^{A}\sum_{i=1}^{N_{aI}}\sum_{j=1}^{N_{aI}} \frac{\pi_{aij} - \pi_{ai}\pi_{ai}}{\pi_{aij}} \frac{\tilde{t}_{aiD}}{\pi_{ai}} \frac{\tilde{t}_{ajD}}{\pi_{aj}}\ . \qquad (5)$$

Note: in the case of simple random cluster sampling (as in NIS),

$$\pi_{ai} = \frac{n_{as}}{N_{aI}}$$

$$\pi_{aij} = \pi_{ai}, \text{if } i = j$$

$$\pi_{aij} = \frac{n_{as}\,(n_{as} - 1)}{N_{aI}\,(N_{aI} - 1)}\ , \text{if } i \neq j$$

Where n_{as} is the number of selected hospitals in stratum *a* and N_{aI} is the number of all hospitals in stratum *a*.

For the second term in (2),

$$\operatorname{E}\left(\hat{T}_D \,\middle|\hat{\beta}\right) = \sum_{a=1}^{N_A}\sum_{i=1}^{N_{aI}}\sum_{k=1}^{N_{aiH}} I(k \in D) \operatorname{logit}^{-1}\left(x_{aik}\hat{\beta}_c \,\middle|c, x_{aik}\right). \qquad (6)$$

To estimate the variance of (6) we apply the delta method to the asymptotic distribution of $\hat{\beta}$:

$$\widehat{\operatorname{Var}}\{\operatorname{E}\left(\hat{T}_D \,\middle|\hat{\beta}\right)\} = \sum_{c=1}^{3} f\left(\hat{\beta}_c\right)\operatorname{AV}\left(\hat{\beta}_c\right) f\left(\hat{\beta}_c\right)^T \qquad (7)$$

Where the vector function of $\hat{\beta}_c$,

$$f(\hat{\beta}) = \sum_{a=1}^{N_A} \sum_{i=1}^{N_{aI}} \sum_{k=1}^{N_{aiH}} I(k \in D \text{ and } k \in c)\, x_k \frac{\exp(x_{aik}\hat{\beta}_c)}{\{1+\exp(x_{aik}\hat{\beta}_c)\}^2} \,,$$

and $\mathrm{AV}(\hat{\beta}_c)$ is the asymptotic covariance matrix of $\hat{\beta}_c$.

Thus, by combining the variance estimates in (5) and (7), we obtain the variance estimate of $\hat{T}_D$:

$$\widehat{\mathrm{Var}}(\hat{T}_D) = \sum_{a=1}^{A} \sum_{i=1}^{N_{aI}} \sum_{j=1}^{N_{aI}} \frac{\pi_{aij} - \pi_{ai}\pi_{ai}}{\pi_{aij}} \frac{\tilde{t}_{aiD}}{\pi_{ai}} \frac{\tilde{t}_{ajD}}{\pi_{aj}} + \sum_{c=1}^{3} f(\hat{\beta}_c)\mathrm{AV}(\hat{\beta}_c)\, f(\hat{\beta}_c)^T$$

The rate estimator is simply the count estimator divided by the corresponding inter-censal population estimate. For the variance calculation, the population estimate is treated as fixed.

Web Table 4. Results of model selection to predict ADHF among those hospitalizations with ICD code 428 in primary position

Variable	Basic Model	Optimal Model	Extended Model
Wald test *P* values			
Age group	0.803	0.609	0.549
Male	0.318	0.410	0.314
Caucasian	0.540	0.961	0.908
Teaching hospital	0.110	0.091	0.115
Heart valve disorder		<0.001	<0.001
Acute myocardial infarction		0.002	0.002
Atrial fibrillation		0.004	0.005
Chronic kidney disease		0.003	0.016
COPD exacerbation			0.110
Anemia			0.143
Measures of model fit, discrimination and calibration			
Hosmer-Lemeshow *P* value	0.906	0.371	0.711
AUC	0.557	0.652	0.655
IDI		0.042 (0.01)*	0.00 (0.01)†

The basic model includes variables forced into all models.
The reduced model includes variables selected through forward stepwise procedure (Wald *P* value < 0.20) and excludes those eliminated through consideration of model fit, discrimination and calibration. The reduced model forms the basis for final validation models (after consideration of position of HF codes).
The extended model Includes all variables selected through forward stepwise procedure (Wald *P* value < 0.20).
* Compared to basic model.
† Compared to optimal model.

Web Table 5. Results of model selection to predict ADHF among those hospitalizations with ICD code 428 in nonprimary position			
Variable	**Basic Model**	**Optimal Model**	**Extended Model**
Wald test *P* values			
Age group	0.682	0.327	0.303
Male	0.019	0.229	0.239
Caucasian	0.391	0.715	0.783
Teaching hospital	0.300	0.002	0.002
Acute myocardial infarction		<0.001	<0.001
Other heart failure		<0.001	<0.001
Pneumonia		<0.001	<0.001
Heart failure code in 2nd position		<0.001	<0.001
Acute kidney injury		<0.001	<0.001
Atrial fibrillation		<0.001	<0.001
Chronic obstructive pulmonary disease		<0.001	<0.001
Heart valve disorder		<0.001	<0.001
Cardiomyopathy		<0.001	<0.001
Other fluid and electrolyte disorders		<0.001	<0.001
Dyspnea and respiratory abnormalities		<0.001	<0.001
Uncomplicated hypertension		<0.001	0.006
Conduction disorder		0.002	0.002
Cardiac dysrhythmias (not AF or atrial flutter)		0.005	0.005
Chronic kidney disease			0.182
Measures of model fit, discrimination and calibration			
Hosmer-Lemeshow *P* value	0.636	0.109	0.246
AUC	0.513	0.727	0.726
IDI		0.063 (0.002)[a]	0.001 (0.002)[b]

The basic model includes variables forced into all models.
The reduced model includes variables selected through forward stepwise procedure (Wald *P* value < 0.20) and excludes those eliminated through consideration of model fit, discrimination and calibration. The reduced model forms the basis for final validation models (after consideration of position of HF codes).
The extended model Includes all variables selected through forward stepwise procedure (Wald *P* value < 0.20).
[*] Compared to basic model.
[†] Compared to optimal model.

Web Table 6. Results of model selection to predict ADHF among those hospitalizations with ICD code 428 absent with other eligible codes

Variable	Basic Model	Reduced Model	Extended Model
Wald test *P* values			
Age group	0.066	0.099	0.075
Male	0.617	0.419	0.309
Caucasian	0.490	0.707	0.605
Teaching hospital	0.005	0.020	0.021
Other heart failure		<0.001	<0.001
Acute myocardial infarction		<0.001	<0.001
Chronic kidney disease		<0.001	<0.001
Other fluid and electrolyte disorders		<0.001	<0.001
Atrial fibrillation		0.002	0.002
Cardiomyopathy in primary position		0.002	0.003
Coronary atherosclerosis or other heart disease			0.049
Measures of model fit, discrimination and calibration			
Hosmer-Lemeshow *P* value	0.362	0.018	0.159
AUC	0.548	0.799	0.800
IDI		0.147 (0.004)[*]	0.002 (0.003)[†]

The basic model includes variables forced into all models.
The reduced model includes variables selected through forward stepwise procedure (Wald $P < 0.20$) and excludes those eliminated through consideration of model fit, discrimination and calibration. The reduced model forms the basis for final validation models (after consideration of position of HF codes).
The extended model Includes all variables selected through forward stepwise procedure (Wald $P < 0.20$).
[*] Compared to basic model.
[†] Compared to reduced model.

Web Table 7. Weighted proportion of sampling codes among ARIC ADHF Surveillance and the NIS

ICD Code	Description	ARIC (2005–2010) Weighted *n* = 52,065		NIS (1998–2011) Weighted *n* = 57 Million	
		Primary Position	Any Position	Primary Position	Any Position
428	HF	19.47	89.46	22.00	87.88
398	Rheumatic HF	0	4.62	0.02	1.62
402	Hypertensive HF	0.21	4.71	0.13	3.38
404	Renal HF	0.16	2.6	0.10	1.97
415/416	Acute/chronic pulmonary heart disease	0.16	5.41	0.28	1.85
425	Cardiomyopathy	2.96	10.45	3.72	14.78
518	Acute lung edema	0.01	0.74	0.01	0.40
786	Dyspnea and respiratory abnormalities	0.51	2.88	0.26	3.83
Total*		23.49	120.87	26.52	115.70

*Some hospitalizations had more than one eligible code.
ADHF, acute decompensated heart failure; ARIC, Atherosclerosis Risk In Communities; NIS, National Inpatient Database.

Web Table 8. Characteristics of heart failure eligible* hospitalizations in ARIC ADHF surveillance and National Inpatient Sample

	ARIC (2005–2010)	NIS (1998–2011)
n (weighted)	12,450 (52065)	11.6M (57.0M)
Age group, y		
55-64	0.20	0.16
65-74	0.25	0.25
≥ 75	0.55	0.60
Male	0.45	0.45
Caucasians†	0.72	0.60**
Heart valve disorder	0.13	0.14
Rheumatic HF	0.01	0.02
Hypertension	0.45	0.40
Hypertensive HF	0.03	0.03
Diabetes	0.45	0.36
Coronary atherosclerosis	0.50	0.48
Acute myocardial infarction	0.07	0.08
Cardiomyopathy	0.15	0.15
Atrial fibrillation	0.27	0.34
Other arrhythmias (non-AF)	0.16	0.13
Conduction disorders	0.10	0.14
Chronic kidney disease	0.29	0.15
Acute kidney injury	0.19	0.12
Fluid and electrolyte disorder	0.10	0.06
Renal HF	0.03	0.02
Dyspnea and respiratory abnormalities	0.07	0.04
COPD exacerbation	0.11	0.10
Pneumonia	0.18	0.16
Pulmonary heart disease	0.02	0.02
Anemia	0.25	0.16
Teaching hospital	0.37	0.40

Abbreviations: ADHF, acute decompensated heart failure; AF, atrial fibrillation; ARIC, Atherosclerosis Risk in Communities; COPD, chronic obstructive pulmonary disease; HF, heart failure.

* Eligible sample of hospitalizations among age ≥55 years are defined by hospital ICD codes as detailed in methods and Web Table 1.

† Estimated among those with nonmissing values as race is missing for 23% hospitalizations in the NIS.

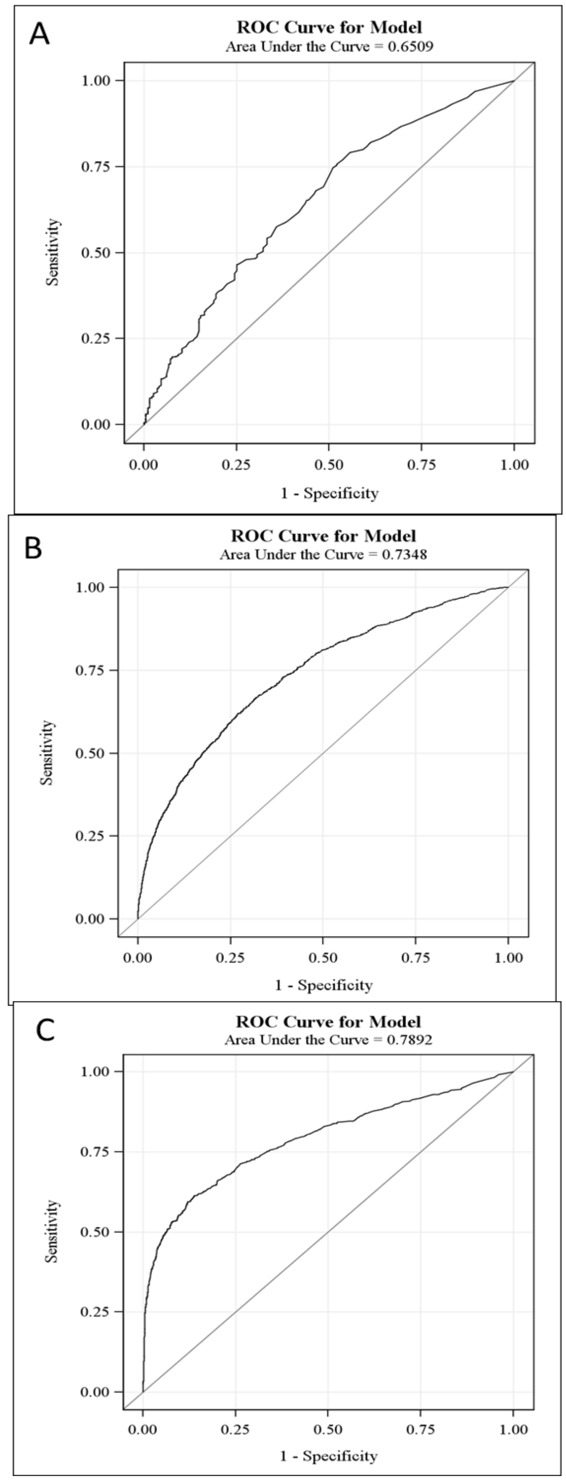
Web Table 9. Multivariable model to predict ADHF among hospitalizations with ICD code 428 in primary position

	Beta Coefficient	Odds Ratio	95% CI		*P* Value
Intercept	1.683				<.0001
Age 65-74 years vs. 55-64 years	-0.222	0.80	0.49	1.32	0.38
Age 75 years or older vs. 55-64 years	-0.225	0.80	0.50	1.27	0.35
Females vs. male	0.145	1.16	0.82	1.64	0.41
Caucasians vs. others	-0.009	0.99	0.68	1.49	0.96
Teaching vs. nonteaching hospital	0.351	1.42	0.95	2.12	0.09
Heart valve disorder	1.166	3.21	1.86	5.52	<.0001
Chronic kidney disease	0.609	1.84	1.24	2.74	<0.01
Acute myocardial infarction	2.258	9.57	2.24	40.84	<0.01
Atrial fibrillation	0.574	1.78	1.20	2.64	<0.01
Optimism-corrected AUC = 0.631	Optimism-corrected calibration slope = 0.864				

Web Table 10. Multivariable model to predict ADHF among hospitalizations with ICD code 428 in nonprimary position

	Beta Coefficient	Odds Ratio	95% CI		*P* Value
Intercept	-1.934				<.0001
Age 65-74 years vs. 55-64 years	-0.131	0.88	0.73	1.06	0.17
Age 75 years or older vs. 55-64 years	-0.093	0.91	0.77	1.08	0.29
Female vs. male	0.062	1.06	0.94	1.21	0.34
Caucasians vs. others	0.001	0.99	0.88	1.15	0.99
Teaching vs. nonteaching hospital	0.215	1.24	1.08	1.42	<0.01
Acute myocardial infarction	1.424	4.16	3.24	5.32	<.0001
Other heart failure in primary position	2.961	19.31	12.22	30.52	<.0001
Other heart failure in nonprimary position	0.642	1.90	1.48	2.43	<.0001
Pneumonia	0.743	2.10	1.79	2.47	<.0001
Heart failure code 428 in 2nd position	0.771	2.16	1.87	2.49	<.0001
Acute kidney injury	0.522	1.69	1.45	1.96	<.0001
Atrial fibrillation	0.416	1.52	1.33	1.74	<.0001
Chronic obstructive pulmonary disease	0.644	1.90	1.58	2.29	<.0001
Heart valve disorder	0.477	1.61	1.33	1.95	<.0001
Cardiomyopathy	0.501	1.65	1.35	2.02	<.0001
Other fluid and electrolyte disorders	0.417	1.52	1.25	1.85	<.0001
Dyspnea and respiratory abnormalities primary	1.478	4.38	2.21	8.69	<.0001
Dyspnea and respiratory abnormalities nonprimary	0.591	1.81	1.18	2.76	<0.01
Uncomplicated hypertension	-0.253	0.78	0.68	0.89	<0.001
Conduction disorder	0.310	1.36	1.17	1.67	<0.01
Cardiac dysrhythmia (not AF or atrial flutter)	0.252	1.29	1.09	1.53	<0.01
Optimism-corrected AUC = 0.734			Optimism-corrected calibration slope = 1.00		

Web Table 11. Multivariable model to predict ADHF among those hospitalizations with ICD code 428 absent with other eligible codes					
	Beta Coefficient	**Odds Ratio**	**95% CI**		***P* Value**
Intercept	-2.904				<.0001
Age 65-74 years vs. 55-64 years	-0.396	0.67	0.47	0.97	0.03
Age 75 years or older vs. 55-64 years	-0.262	0.77	0.54	1.09	0.14
Females vs. male	-0.021	0.98	0.75	1.28	0.88
Caucasians vs. others	-0.004	1.03	0.79	1.35	0.98
Teaching vs. nonteaching hospital	0.291	1.34	1.01	1.77	0.04
Other heart failure in primary position	4.469	87.29	43.96	173.30	<.0001
Other heart failure in nonprimary position	1.888	6.61	4.70	9.30	<.0001
Acute myocardial infarction	1.322	3.75	2.37	5.92	<.0001
Chronic kidney disease	0.701	2.02	1.48	2.75	<0.001
Other fluid and electrolyte disorders	0.849	2.34	1.62	3.37	<.01
Atrial fibrillation	0.455	1.58	1.19	2.08	<0.01
Cardiomyopathy in primary position	1.581	4.86	2.49	9.48	<0.001
Cardiomyopathy in nonprimary position	0.361	1.44	1.03	2.00	0.03
Optimism-corrected AUC = 0.807	Optimism-corrected calibration slope = 1.03				



Web Figure 1. Area under the receiver operating characteristic (ROC) curve (AUC) for risk score to predict hospitalized ADHF with predictors that include age, sex, teaching hospital status, and comorbidity defined with discharge codes for 428 primary (A), nonprimary (B), and absent (C).

Web Table 12. Frequency of hospitalization by ICD-9-CM code 428 group

Year	Code 428 in Primary Position		Code 428 in Nonprimary Position		Code 428 Absent	
	Frequency	SD	Frequency	SD	Frequency	SD
1998	890962	34535	2189319	88402	567203	24827
1999	868367	34115	2190989	89011	553378	24457
2000	895087	35014	2296143	94560	565858	24324
2001	916546	35887	2379843	96417	596250	25758
2002	913181	36710	2502076	103384	557740	24176
2003	964841	39065	2734050	112220	426636	17873
2004	944326	37776	2832909	115963	394506	17061
2005	929129	37709	2928677	120616	421119	19224
2006	923017	37926	2974077	122685	458451	21310
2007	860950	34604	2868838	116465	466020	20548
2008	869330	35320	2842275	117832	533613	24845
2009	880859	36794	2860827	120034	488718	22745
2010	841580	34792	2874857	120209	430999	18955
2011	850855	34708	3097806	131097	455369	20509

ADHF, acute decompensated heart failure; ICD-9-CM, *International Classification of Diseases, Ninth Revision, Clinical Modification*; SD, standard deviation.

Data from the National Inpatient Sample.

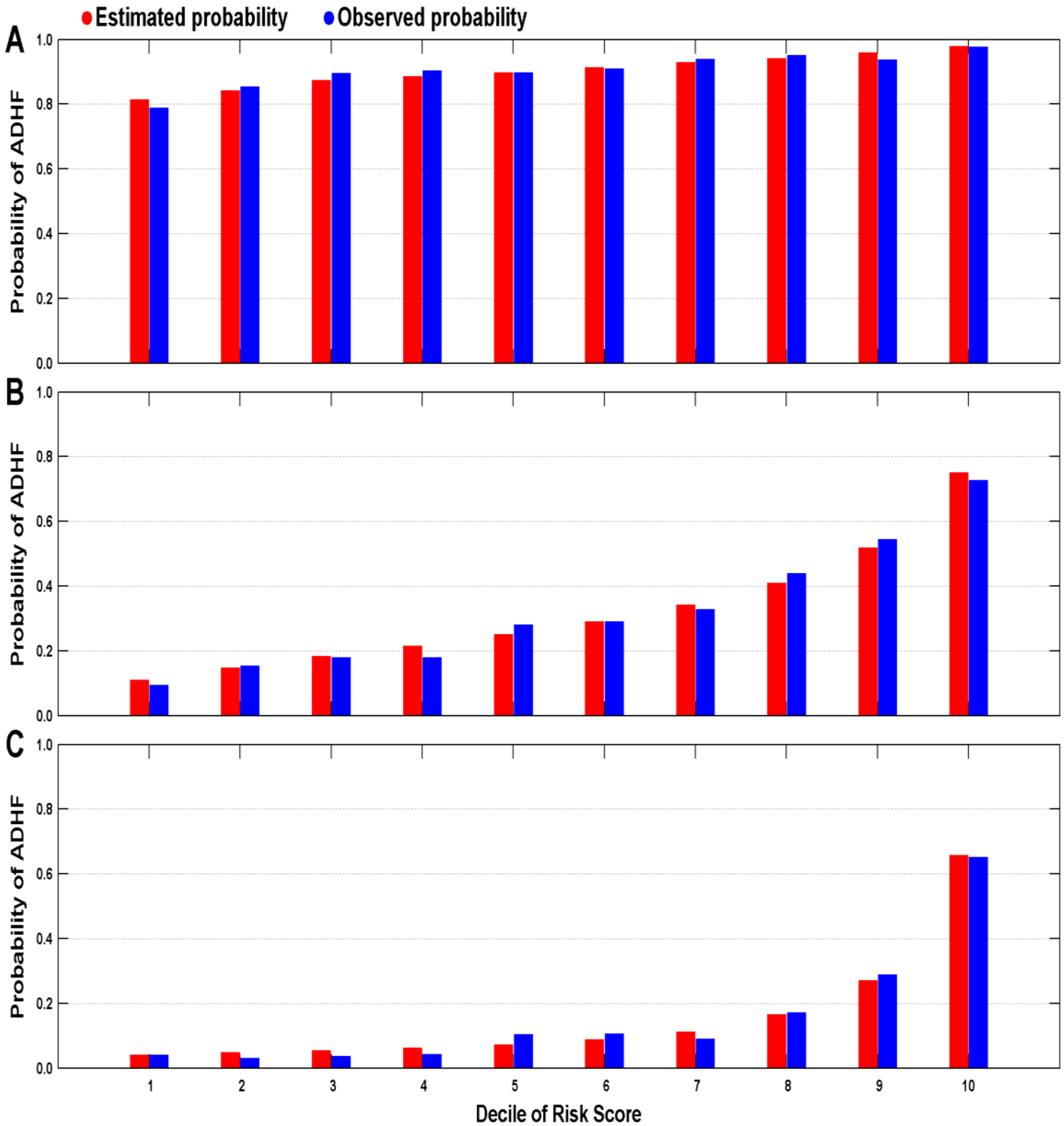
Web Table 13. Annual percentage change in the estimates for hospitalizations, hospitalization rates, estimated ADHF, and estimated ADHF rate by ICD-9-CM code 428 group			
		1998–2004	**2005–2011**
		Annual % change (95% CI)	
Hospitalizations			
	Primary	1.4 (0.8, 2.1)	-1.5 (-2.2, -0.8)
	Nonprimary	4.6 (3.7, 5.4)	0.3 (-0.8, 1.2)
	Absent	-6.5 (-10.1, -4.5)	0.6 (-2.4, 2.3)
Hospitalization rate			
	Primary	-0.7 (-1.3, -0.1)	-4.2 (-4.8, -3.5)
	Nonprimary	2.4 (1.8, 3.1)	-2.5 (-3.4, -1.5)
	Absent	-8.5 (-11.6, -5.4)	-2.2 (-4.5, 0.2)
Estimated ADHF			
	Primary	1.5 (0.9, 2.9)	-1.2 (-1.8, -0.5)
	Nonprimary	5.8 (4.6, 7.1)	0.6 (-1.0, 2.1)
	Absent	-17.2 (-21.9, -12.1)	-8.9 (-13.2, -4.4)
	Total	2.0 (1.6, 2.5)	-0.5 (-1.4, 0.3)
Estimated ADHF rate			
	Primary	-0.7(-1.2, -0.1)	-3.9(-4.5, -3.3)
	Nonprimary	3.6 (2.6, 4.7)	-2.2(-3.7, -0.7)
	Absent	-19.0 (-23.8, -14 .0)	-11.4 (-15.6, -7.0)
	Total	-0.1(-0.6, 0.3)	-3.2 (-4.1, -2.4)
Estimates were based on National Inpatient Sample of hospitalizations with ICD code 428.xx in the primary position, vs. nonprimary position, vs. other absent with other eligible ICD code. ADHF frequency and rates are based on estimations using validated models in the ARIC study. US Census data were used for estimation of rates. Figure 3 shows the trends. CI, confidence interval.			

Web Table 14. Estimated ADHF hospitalizations by ICD-9-CM codes 428 groups and overall								
Year	**Code 428 in Primary Position**		**Code 428 in Nonprimary Position**		**Code 428 Absent**		**Total**	
	Frequency	**SD**	**Frequency**	**SD**	**Frequency**	**SD**	**Frequency**	**SD**
1998	791297	31056	632198	26633	212324	10372	1635819	64967
1999	771369	30695	641004	27459	195154	9557	1607527	64867
2000	793680	31465	666960	28893	194341	9356	1654981	66997
2001	813457	32255	693758	29665	198836	9535	1706050	68857
2002	811669	33027	745516	32418	174935	8370	1732119	71702
2003	859092	35189	850516	36323	94614	4584	1804223	74271
2004	841276	34034	879857	37458	82981	4190	1804115	73973
2005	830608	34163	915668	39892	89447	5023	1835723	77273
2006	832442	34623	942714	40849	101516	5705	1876672	79151
2007	781585	31755	909107	39013	102259	5152	1792950	74071
2008	788655	32367	865644	37916	107813	5838	1762112	74079
2009	801146	33806	894866	39611	80416	4184	1776427	76107
2010	767130	32011	911541	40057	59579	2894	1738251	73646
2011	777056	32009	1005922	44911	63915	3235	1846892	78651

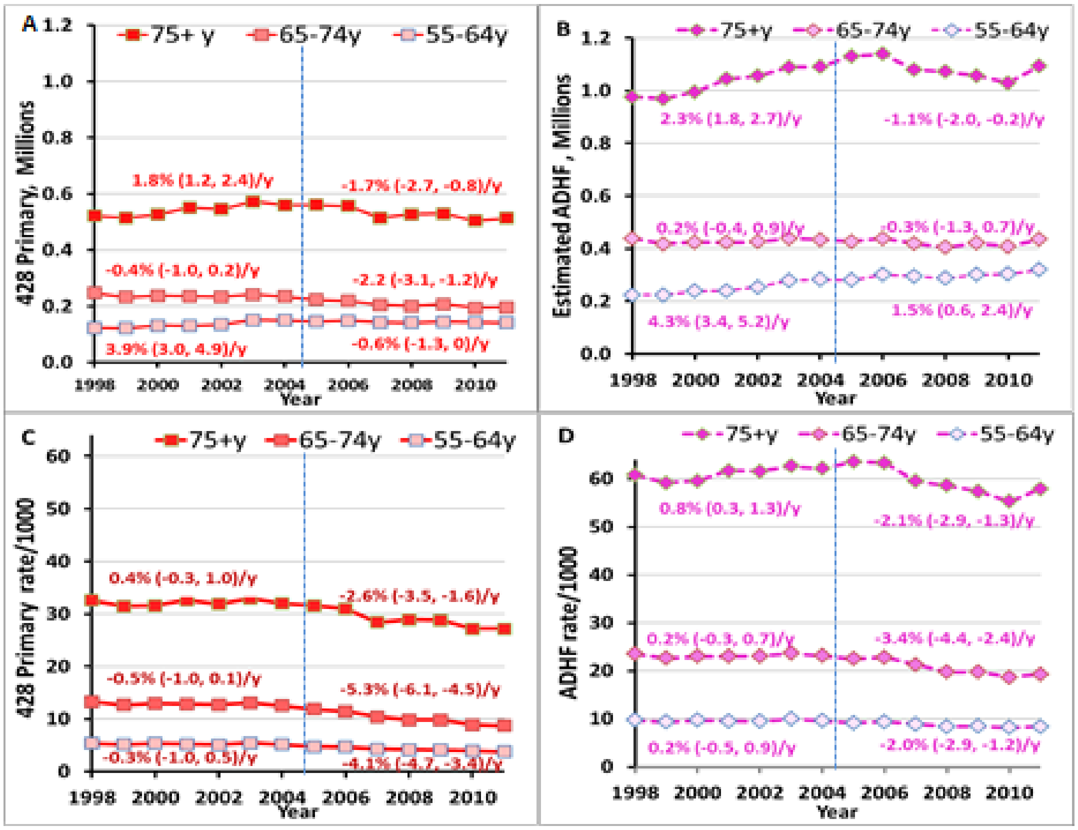
ADHF, acute decompensated heart failure; ARIC, Atherosclerosis Risk in Communities; ICD-9-CM, *International Classification of Diseases, Ninth Revision, Clinical Modification*; SD, standard deviation.

Estimates were obtained by application of models derived in an ARIC ADHF validation study to the National Inpatient Sample.

WEB FIGURES 2 AND 3



Web Figure 2. Predicted versus observed probability of acute decompensated heart failure (ADHF) hospitalization by decile of risk scores derived for 428 primary (A), nonprimary (B), and absent (C), separately.



Web Figure 3. Comparison of hospitalizations with ICD-9-CM code 428 primary with acute decompensated heart failure (ADHF) in the United States during 1998–2011, by age group. Panels show discharge code 428 in primary position (A), estimated ADHF hospitalizations (B), and corresponding rates per 1000 persons for 428 primary (C), and estimated ADHF (D). Trends for 1998–2004 and 2005–2011 are shown as annual percent change.