Readmission and mortality among heart failure patients with history of hypertension in a statewide database

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Abstract:	Objective was to examine the temporal trends in readmission and mortality of heart failure (HF) patients with history of hypertension. This study includes 51,141 patients with history of hypertension who were discharged with a first diagnosis of HF between January 1, 2000 and December 31, 2014. Data were obtained from the Myocardial Infarction Data Acquisition System (MIDAS), a statewide database of all hospitalizations for cardiovascular disease in New Jersey. The temporal trends of mortality, rates of HF specific readmission and all-cause readmissions up to one year after discharge were examined using multivariable logistic regression. The difference in all-cause mortality at 3 years between patients who were readmitted compared to those who were not readmitted at one year was examined. The number of patients with history of hypertension and HF remained unchanged during the study period. Male gender, black race, comorbid conditions and admission to non-teaching hospitals were predictors of HF readmission and CV mortality ($p<0.05$ for all). Readmission rate for any cause increased during the study period ($p<0.001$) while rates of HF readmissions and mortality remained relatively unchanged. Patients that had been readmitted within a year exhibited a significantly higher 3-year mortality ($p<0.001$). In conclusion CV mortality among HF patients with history of hypertension did not change significantly between 2000 and 2014, while the rates of all-cause readmission increased. Patients who were readmitted had higher 3-year mortality ($p<0.001$) than those who

	were not.

Table 1. Number of first heart failure admissions by year

Year	Counts	First heart failure diagnosis
2000	3,303	74.4
2001	3,300	74.5
2002	3,540	74.2
2003	3,566	74.7
2004	3,300	74.5
2005	3,276	75.3
2006	3,084	75.2
2007	3,065	75.3
2008	3,465	74.9
2009	3,510	75.5
2010	3,576	75.1
2011	3,474	74.7
2012	3,408	75.2
2013	3,623	74.9
2014	3,651	74.9
TOTAL	51,141	

Table 2. Heart failure patients with history of hypertension characteristics

Description	Number of Patients	Percent Patients
Mean age at first heart failure admission +/- S.D	74.9 +/-14.1	
Male(%)	22,888	44.8
Race (%)		
White	38,262	74.8
Black	7,992	15.6
Other	4,887	9.6
Ethnicity (%)		
Hispanic	4,007	7.8
Non-Hispanic	42,909	83.9
Unknown	4,225	8.3
Insurance (%)		
Commercial	12,871	25.2
Medicare	35,719	69.8
Medicaid/Self-Pay/Other	2,551	5
Admission Hospital Type (%)		
Teaching	24,420	47.8
Non-Teaching	24,965	48.8
Unknown	1,756	3.4
Admission to Hospital Area (%)		
Urban	12,310	24.1
Inner city	9,168	17.9
Rural	6,194	12.1
Suburb	21,713	42.5

Unknown	1,756	3.4
Admission Hospital Cath Lab		
Cath Lab	22,410	43.8
No Cath Lab	26,975	52.7
Unknown	1,756	3.4
Number of Heart Failure Patients	51,141	

Table 3. All-cause readmissions

Risk Factor	30-Day	90-Day	180-Day	1-Year
Chronic Kidney Disease	1.297 (1.206, 1.394) <0.001	1.309 (1.228, 1.395) <0.001	1.326 (1.244, 1.395) <0.001	1.35 (1.26, 1.446) <0.001
Stroke	1.252 (0.967, 1.621) 0.088	1.222 (0.973, 1.535) 0084	1.191 (0.95, 1.493) 0.130	1.282 (1.007, 1.631) 0.044
Parkinson	1.199 (1.024, 1.405) 0.024	1.194 (1.041, 1.37) 0.011	1.112 (0.971, 1.273) 0.124	1.219 (1.059, 1.404) 0.006
Anemia	1.190 (1.132, 1.251) <0.001	1.198 (1.148, 1.251) <0.001	1.205 (1.156, 1.257) <0.001	1.203 (1.151, 1.257) <0.001
Diabetes	1.120 (1.07, 1.173) <0.001	1.16 (1.116, 1.206) <0.001	1.194 (1.15, 1.24) <0.001	1.228 (1.181, 1.277) <0.001
Chronic Obstructive Pulmonary Disease	1.132 (1.077, 1.19) <0.001	1.162 (1.114, 1.212) <0.001	1.195 (1.146, 1.245) <0.001	1.249 (1.196, 1.304) <0.001
Length of Stay	1.128 (1.101, 1.156) <0.001	1.121 (1.098, 1.144) <0.001	1.09 (1.069, 1.112) <0.001	1.038 (1.017, 1.059) <0.001
Acute Myocardial Infarction	1.098 (1.03, 1.17) 0.004	1.07 (1.013, 1.13) 0.0015	1.027 (0.974, 1.084) 0.320	1.001 (0.948, 1.058) 0.959
Area: Inner City Area vs. Urban	1.047 (0.977, 1.122) 0.191	1.066 (1.006, 1.13) 0.031	1.039 (0.982, 1.1) 0.186	1.034 (0.975, 1.096) 0.263
Hosp: Non-Teaching vs. Teaching	1.064 (1.003, 1.129) 0.040	1.046 (0.995, 1.1) 0.076	1.075 (1.024, 1.128) <0.003	1.098 (1.045, 1.154) <0.001
Discharge year	1.022 (1.016, 1.028) <0.001	1.02 (1.015, 1.024) <0.001	1.019 (1.014, 1.024) <0.001	1.013 (1.008, 1.017) <0.001
Area: Suburb Area vs. Urban	1.008 (0.953, 1.066) 0.782	1.038 (0.99, 1.088) 0.124	1.006 (0.961, 1.053) 0.797	0.983 (0.937, 1.03) 0.464
Hyperlipidemia	1.021 (0.974, 1.07) 0.388	1.081 (1.038, 1.125) <0.001	1.096 (1.054, 1.139) <0.001	1.141 (1.097, 1.187) <0.001
Atrial Fibrillation/Atrial Flutter	1.021 (0.971, 1.073) 0.425	1.045 (1.002, 1.091) 0.040	1.054 (1.012, 1.098) 0.0012	1.083 (1.038, 1.129) <0.001
Insurance: Medicaid/Self-Pay/Other vs. Medicare	1.071 (0.96, 1.194) 0.220	0.964 (0.878, 1.059) 0.446	1.013 (0.925, 1.11) 0.775	1.054 (0.958, 1.16) 0.282
Male vs. Female	0.969 (0.925, 1.014) 0.175	0.975 (0.938, 1.014) 0.202	0.963 (0.928, 1.0) 0.050	0.939 (0.904, 0.976) <0.001
Age (X10)	0.966 (0.947, 0.985) <0.001	0.954 (0.938, 0.97) <0.001	0.939 (0.924, 0.955) <0.001	0.929 (0.914, 0.945) <0.001

Hospital: No Cath Lab vs. Cath Lab	0.98 (0.924, 1.039) 0.501	1.01 (0.961, 1.061) 0.707	0.998 (0.952, 1.047) 0.944	1.019 (0.97, 1.07) 0.459
Race: Other vs. White	0.937 (0.867, 1.014) 0.106	0.91 (0.852, 0.972) 0.005	0.95 (0.891, 1.013) 0.115	0.964 (0.903, 1.03) 0.278
Race: Black vs. White	0.954 (0.891, 1.022) 0.179	1.031 (0.973, 1.092) 0.298	1.11 (1.05, 1.174) <0.001	1.129 (1.066, 1.197) <0.001
Ethnicity: Non-Hispanic vs. Hispanic	0.947 (0.868, 1.032) 0.214	0.841 (0.781, 0.904) <0.001	0.858 (0.798, 0.922) <0.001	0.87 (0.807, 0.937) <0.001
Sleep Apnea	0.92 (0.787, 1.075) 0.294	0.887 (0.776, 1.013) 0.077	0.946 (0.831, 1.078) 0.405	1.00 (0.871, 1.148) 1.000
Insurance: Commercial vs. Medicare	0.899 (0.848, 0.953) <0.001	0.873 (0.831, 0.917) <0.001	0.864 (0.824, 0.906) <0.001	0.883 (0.841, 0.927) <0.001
Ethnicity: Unknown vs. Hispanic	0.871 (0.777, 0.976) 0.018	0.781 (0.71, 0.859) <0.001	0.8 (0.729, 0.877) <0.001	0.809 (0.736, 0.89) <0.001
Area: Rural Area vs. Urban	0.866 (0.797, 0.94) <0.001	0.878 (0.82, 0.941) <0.001	0.842 (0.789, 0.899) <0.001	0.822 (0.769, 0.878) <0.001
Transient Ischemic Attack	0.851 (0.65, 1.114) 0.241	0.891 (0.703, 1.129) 0.339	0.919 (0.726, 1.162) 0.480	0.859 (0.669, 1.103) 0.233

Table 4. Heart failure readmissions

Risk Factor	30-Day	90-Day	180-Day	1-Year
Stroke	1.917 (1.349, 2.722) <0.001	1.435 (1.06, 1.942) 0.019	1.398 (1.064, 1.836) 0.016	1.535 (1.202, 1.96) <0.001
Hospital: No Cath Lab vs. Cath Lab	1.175 (1.065, 1.296) 0.001	1.098 (1.019, 1.183) 0.014	1.08 (1.012, 1.153) 0.020	1.047 (0.987, 1.11) 0.010
Acute Myocardial Infarction	1.219 (1.1, 1.351) <0.001	1.195 (1.105, 1.293) <0.001	1.133 (1.057, 1.215) <0.001	1.12 (1.052, 1.193) <0.001
Insurance: Medicaid/Self-Pay/Other vs. Medicare	1.27 (1.074, 1.502) 0.005	1.244 (1.092, 1.417) 0.001	1.235 (1.101, 1.386) <0.001	1.19 (1.072, 1.321) 0.001
Area: Suburb Area vs. Urban	1.096 (0.997, 1.204) 0.058	1.053 (0.98, 1.131) 0.157	1.051 (0.987, 1.119) 0.122	1.01 (0.955, 1.068) 0.719
Diabetes	1.11 (1.029, 1.198) 0.007	1.153 (1.088, 1.221) <0.001	1.172 (1.114, 1.233) <0.001	1.208 (1.154, 1.264) <0.001
Race: Black vs. White	1.053 (0.942, 1.178) 0.360	1.14 (1.048, 1.24) 0.002	1.21 (1.125, 1.302) <0.001	1.248 (1.169, 1.333) <0.001
Chronic Kidney Disease	1.106 (0.978, 1.25) 0.108	1.1 (1.001, 1.209) 0.048	1.073 (0.987, 1.166) 0.098	1.078 (1, 1.162) 0.050
Length of Stay	1.06 (1.018, 1.103) 0.005	1.055 (1.023, 1.087) <0.001	1.058 (1.03, 1.086) <0.001	1.034 (1.009, 1.058) <0.001
Anemia	1.051 (0.966, 1.145) 0.249	1.026 (0.962, 1.095) 0.434	1.026 (0.969, 1.086) 0.376	1.037 (0.986, 1.091) 0.157
Hospital: Non-Teaching vs. Teaching	1.006 (0.912, 1.11) 0.897	1.032 (0.957, 1.112) 0.417	1.072 (1.004, 1.145) 0.037	1.092 (1.03, 1.159) 0.003
Area: Inner City Area vs. Urban	1.036 (0.922, 1.163) 0.554	1.071 (0.981, 1.168) 0.124	1.107 (1.026, 1.194) 0.009	1.073 (1.003, 1.149) 0.040
COPD	1.023 (0.941, 1.112) 0.594	1.047 (0.983, 1.116) 0.152	1.059 (1.002, 1.119) 0.043	1.086 (1.033, 1.141) 0.001
Discharge year	1.012 (1.002, 1.021) 0.013	1.007 (1, 1.014) 0.047	1.006 (1, 1.013) 0.040	0.999 (0.993, 1.004) 0.707
Area: Rural Area vs. Urban	0.995 (0.87, 1.137) 0.941	0.985 (0.89, 1.09) 0.770	0.941 (0.86, 1.029) 0.183	0.936 (0.864, 1.014) 0.105
Atrial Fibrillation/Atrial Flutter	0.994 (0.913, 1.082) 0.892	1.055 (0.99, 1.125) 0.098	1.076 (1.017, 1.137) 0.010	1.063 (1.011, 1.117) 0.017

Hyperlipidemia	0.956 (0.884, 1.035) 0.264	1.031 (0.971, 1.095) 0.314	1.045 (0.992, 1.101) 0.100	1.055 (1.007, 1.106) 0.024
Race: Other vs. White	0.914 (0.802, 1.043) 0.183	0.899 (0.813, 0.994) 0.038	0.914 (0.837, 0.998) 0.046	0.966 (0.894, 1.044) 0.382
Age (X10)	0.962 (0.932, 0.994) 0.019	0.99 (0.966, 1.015) 0.429	0.989 (0.967, 1.01) 0.305	0.984 (0.964, 1.005) 0.111
Insurance: Commercial vs. Medicare	0.976 (0.886, 1.074) 0.616	0.93 (0.864, 1.001) 0.055	0.914 (0.857, 0.975) 0.007	0.919 (0.868, 0.974) 0.004
Male vs. Female	1.079 (1, 1.164) 0.051	1.059 (1,1.122) 0.052	1.05 (0.998, 1.104) 0.061	1.051 (1.005, 1.1) 0.030
Ethnicity: Non-Hispanic vs. Hispanic	0.858 (0.747, 0.985) 0.030	0.806 (0.726, 0.895) <0.001	0.834 (0.76, 0.915) <0.001	0.833 (0.767, 0.906) <0.001
Sleep Apnea	0.803 (0.61, 1.057) 0.117	0.775 (0.627, 0.959) 0.019	0.789 (0.656, 0.949) 0.012	0.814 (0.693, 0.958) 0.013
Ethnicity: Unknown vs. Hispanic	0.723 (0.598, 0.875) <0.001	0.765 (0.664, 0.88) <0.001	0.813 (0.719, 0.92) <0.001	0.781 (0.699, 0.872) <0.001
Parkinson	0.767 (0.561, 1.049) 0.097	0.834 (0.666, 1.045) 0.114	0.871 (0.718, 1.057) 0.162	0.921 (0.778, 1.091) 0.342
Transient Ischemic Attack	0.472 (0.324, 0.687) <0.001	0.65 (0.472, 0.894) 0.008	0.681 (0.511, 0.907) 0.009	0.653 (0.505, 0.843) 0.001

Table 5. All-cause death

Risk Factor	30-Day	90-Day	180-Day	1-Year
Length of Stay	1.753 (1.668, 1.842) <0.001	1.691 (1.632, 1.753) <0.001	1.58 (1.533, 1.629) <0.001	1.463 (1.425, 1.501) <0.001
Age (X10)	1.667 (1.589, 1.75) <0.001	1.62 (1.567, 1.675) <0.001	1.592 (1.548, 1.636) <0.001	1.567 (1.531, 1.604) <0.001
Ethnicity: Non-Hispanic vs. Hispanic	1.305 (1.048, 1.625) 0.017	1.39 (1.193, 1.618) <0.001	1.458 (1.285, 1.655) <0.001	1.442 (1.297, 1.602) <0.001
Ethnicity: Unknown vs. Hispanic	1.388 (1.07, 1.801) 0.014	1.402 (1.168, 1.683) <0.001	1.393 (1.195, 1.624) <0.001	1.364 (1.199, 1.552) <0.001
Parkinson	1.221 (0.934, 1.596) 0.145	1.371 (1.136, 1.655) 0.001	1.335(1.132, 1.575) <0.001	1.335 (1.151, 1.547) <0.001
Chronic Kidney Disease	1.294 (1.123, 1.491) <0.001	1.327 (1.198, 1.47) <0.001	1.337 (1.225, 1.459) <0.001	1.369 (1.267, 1.478) <0.001
Stroke	1.188 (0.731, 1.933) 0.487	1.518 (1.1, 2.096) 0.011	1.588 (1.204, 2.094) 0.001	1.525 (1.188, 1.957) <0.001
Acute Myocardial Infarction	1.172 (1.031, 1.332) 0.015	1.218 (1.113, 1.334) <0.001	1.205 (1.116, 1.301) <0.001	1.229 (1.15, 1.313) <0.001
Anemia	1.136 (1.031, 1.252) 0.010	1.145 (1.068, 1.228) <0.001	1.256 (1.185, 1.333) <0.001	1.296 (1.231, 1.364) <0.001
Area: Suburb Area vs. Urban	1.153 (1.032, 1.287) 0.012	1.061 (0.981, 1.147) 0.136	1.061 (0.993, 1.134) 0.079	1.054 (0.996, 1.117) 0.071
Chronic Obstructive Pulmonary Disease	1.183 (1.073, 1.305) <0.001	1.177 (1.097, 1.262) <0.001	1.185 (1.117, 1.257) <0.001	1.228 (1.167, 1.293) <0.001
Area:Rural Area vs. Urban	1.207 (1.03, 1.413) 0.020	1.061 (0.948, 1.188) 0.300	1.037 (0.942, 1.141) 0.458	0.984 (0.906, 1.069) 0.707
Hospital: No Cath Lab vs. Cath Lab	1.03 (0.922, 1.151) 0.602	1.025 (0.946, 1.11) 0.549	1.012 (0.946, 1.084) 0.723	1.036 (0.977, 1.1) 0.237
Atrial Fibrillation/Atrial Flutter	1.096 (0.999, 1.202) 0.052	1.055 (0.987, 1.128) 0.115	1.047 (0.989, 1.108) 0.113	1.013 (0.964, 1.064) 0.620
TIA	1.11 (0.671, 1.838) 0.685	0.835 (0.596, 1.17) 0.295	0.792 (0.593, 1.057) 0.113	0.819 (0.631, 1.062) 0.132
Sleep Apnea	0.962 (0.646, 1.432) 0.848	0.89 (0.67, 1.183) 0.422	0.886 (0.701, 1.119) 0.310	0.885 (0.728, 1.076) 0.222
Discharge year	1.028 (1.016, 1.039) <0.001	1.021 (1.013, 1.029) <0.001	1.015 (1.008, 1.022) <0.001	1.006 (1.001, 1.012) 0.030

Area: Inner City Area vs. Urban	0.918 (0.785, 1.075) 0.288	0.924 (0.83, 1.029) 0.152	0.982 (0.898, 1.073) 0.684	0.97 (0.899, 1.047) 0.438
Hospital: Non-Teaching vs. Teaching	0.953 (0.853, 1.065) 0.393	1.006 (0.929, 1.09) 0.875	1.003 (0.937, 1.074) 0.924	1.02 (0.961, 1.082) 0.516
Diabetes	0.953 (0.6, 1.049) 0.329	0.969 (0.905, 1.037) 0.357	0.983 (0.929, 1.041) 0.566	1 (0.953, 1.05) 0.991
Insurance: Medicaid/Self-Pay/Other vs. Medicare	0.88 (0.612, 1.266) 0.492	0.905 (0.715, 1.145) 0.405	0.984 (0.82, 1.181) 0.863	1.003 (0.867, 1.161) 0.964
Insurance: Commercial vs. Medicare	0.895 (0.784, 1.021) 0.100	0.865 (0.788, 0.948) 0.002	0.838 (0.776, 0.905) <0.001	0.803 (0.752, 0.857) <0.001
Male vs. Female	1.173 (1.071, 1.285) <0.001	1.179 (1.105, 1.258) <0.001	1.183 (1.12, 1.25) <0.001	1.177 (1.122, 1.234) <0.001
Race: Other vs.White	0.79 (0.66, 0.946) 0.010	0.836 (0.739, 0.945) 0.004	0.843 (0.761, 0.934) 0.001	0.83 (0.761, 0.906) <0.001
Hyperlipidemia	0.736 (0.668, 0.811) <0.001	0.747 (0.698, 0.8) <0.001	0.768 (0.725, 0.813) <0.001	0.769 (0.732, 0.808) <0.001
Race: Black vs. White	0.731 (0.616, 0.869) <0.001	0.783 (0.698, 0.879) <0.001	0.832 (0.758, 0.914) <0.001	0.904 (0.837, 0.977) 0.011

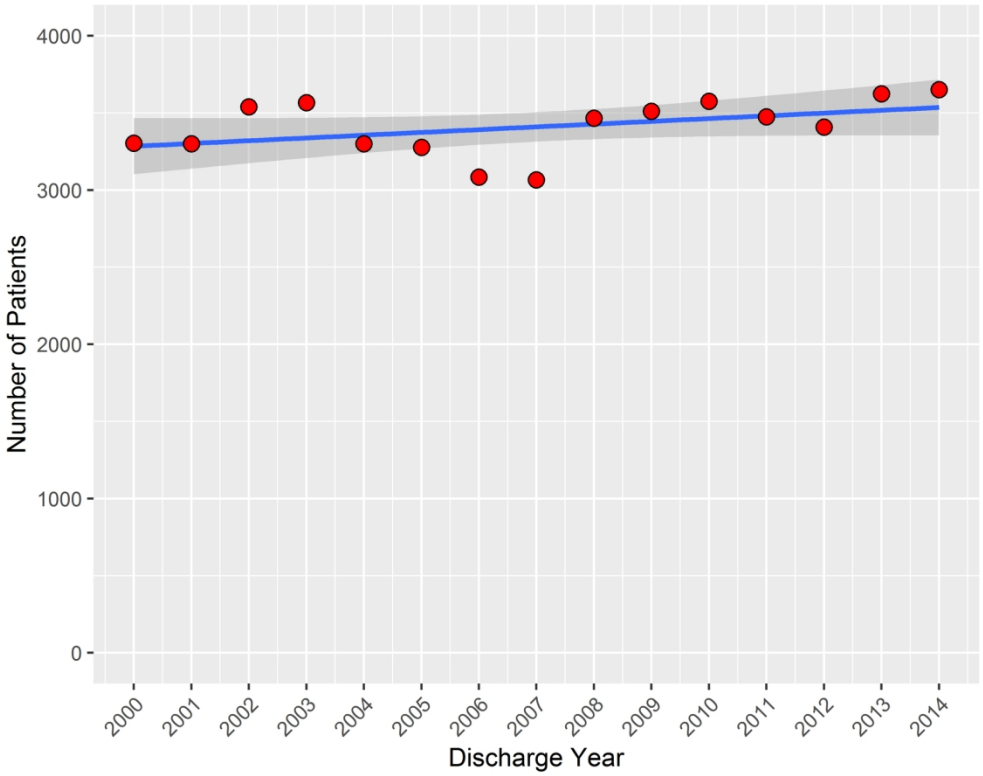

Figure 1: number of first HF discharges. Total of 51,141 patients with history of hypertension, no prior HF.

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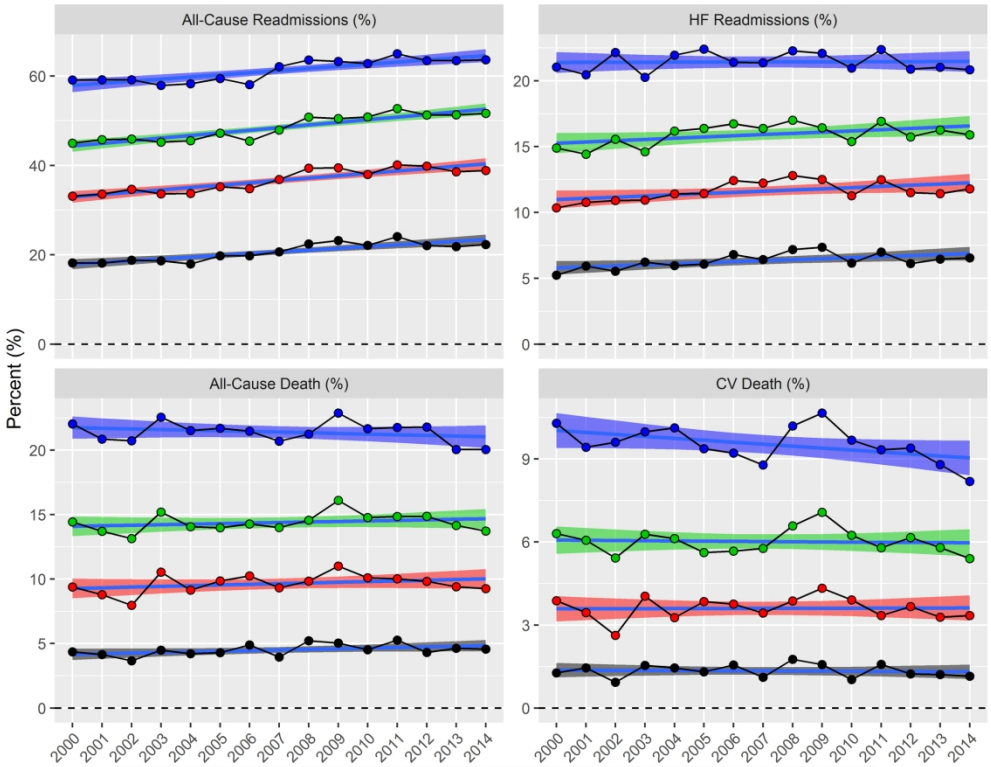

Outcome	Slope	95% CI	p-Value	Significance
All-Cause Readmissions (%)	0.478	0.317 to 0.639	<0.001	**
HF Readmissions (%)	0.005	-0.082 to 0.093	0.907	
All-Cause Death (%)	-0.050	-0.146 to 0.045	0.323	
CV Death (%)	-0.071	-0.14 to -0.001	0.067	

Figure 2: cardiovascular outcome trends in HF patients with history of hypertension.

203x203mm (300 x 300 DPI)

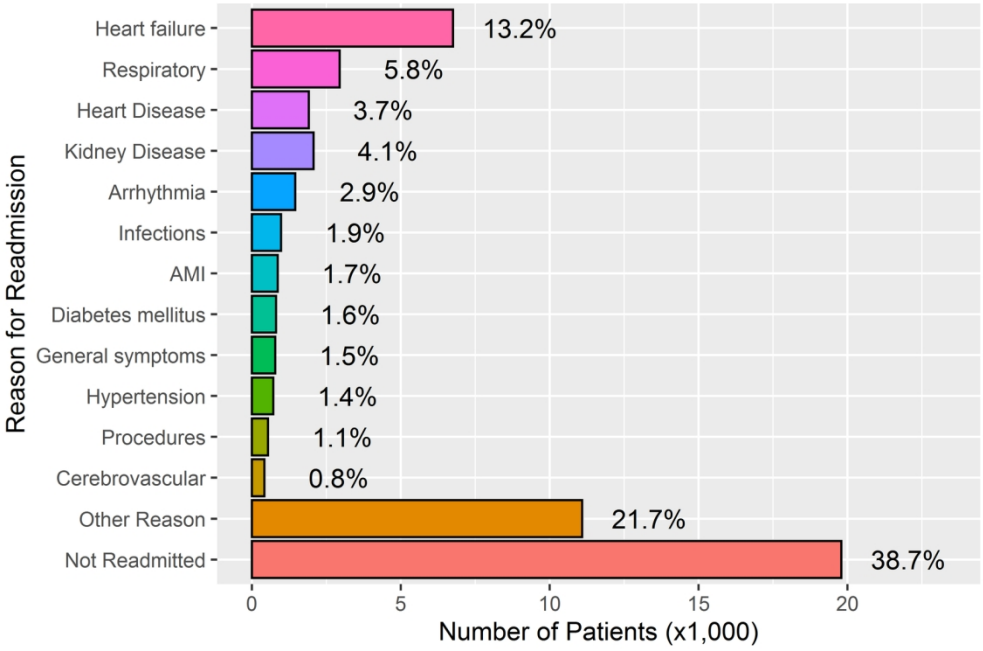

Figure 3: HF patients with history of hypertension readmissions by reason for readmission.

152x101mm (300 x 300 DPI)

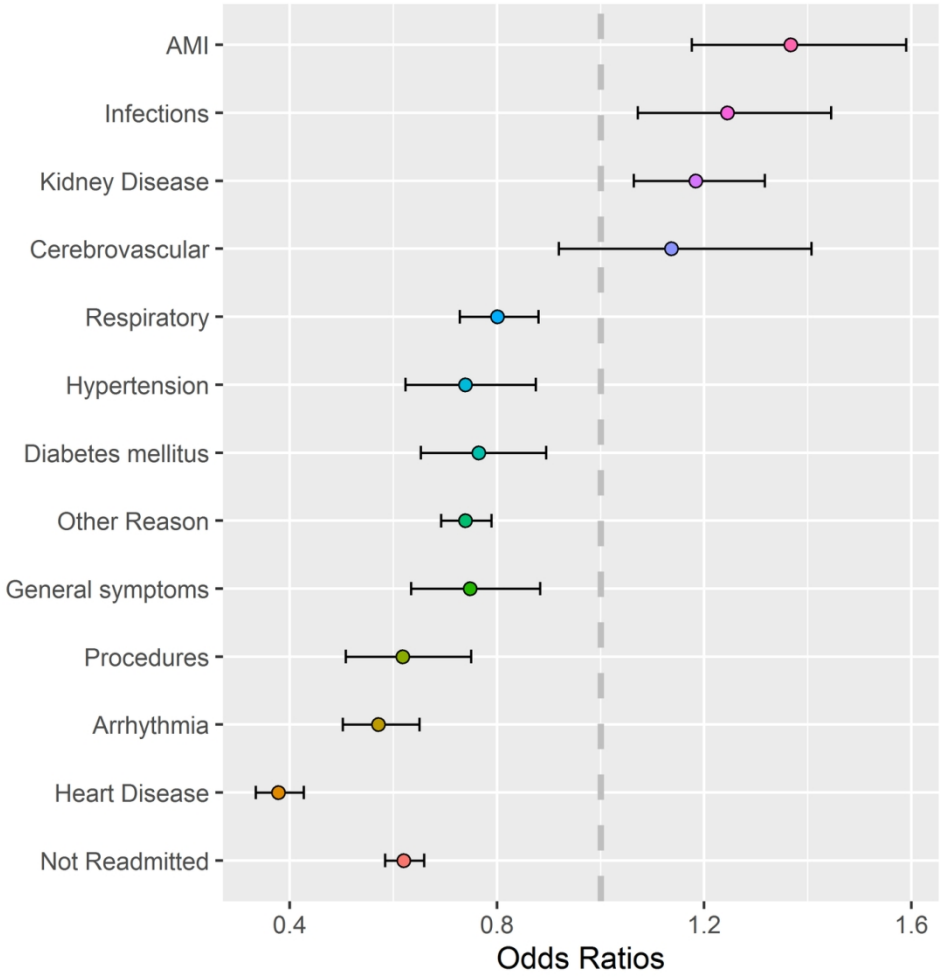

Figure 4: odds ratios of 3-year all-cause mortality by reason for readmission.

127x127mm (300 x 300 DPI)

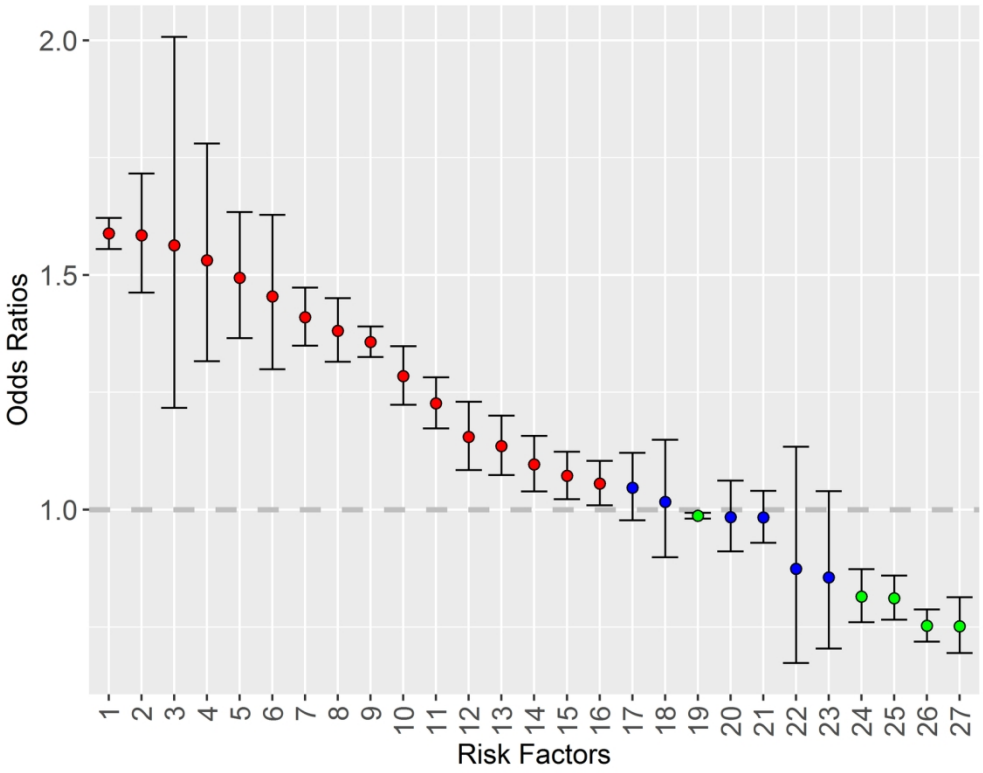

Figure 5: odds ratios of 3-year all-cause mortality adjusted for all covariates. 1. Age (x10) 2. CKD 3. Stroke 4. Parkinson's Disease 5. Ethnicity: Non-hispanic vs. Hispanic 6. Ethnicity: Unknown vs. Hispanic 7. 1-year all-cause readmission 8. Anemia 9. Length of stay 10. COPD 11. Male vs. Female 12. History of acute myocardial infarction 13. Hospital: No cath-lab vs. cath-lab 14. Area: Suburb area vs. Urban area 15. Atrial Fibrillation/Flutter 16. Diabetes 17. Area: Inner city area vs. Urban area 18. Insurance: Medicaid/Self-pay/other vs. Medicare 19. Discharge year 20. Area: Rural area vs. Urban area 21. Hospital: Non-teaching vs Teaching 22. Transient Ischemic Attack 23. Sleep Apnea 24. Race: Black vs. White 25. Commercial vs. Medicare 26. Hyperlipidemia 27. Race: Other vs. White

152x127mm (300 x 300 DPI)

Supplementary Online Content

Giakoumis M, Sargsyan D, Kostis JB, Cabrera J, Dalwadi S, Kostis WJ For the Myocardial Infarction Data Acquisition System (MIDAS) Study Group.

Supplementary Table 1. ICD-9 Codes for Comorbidities

AFib/AFlutter	427.31; 427.32
AMI	410.00; 410.01; 410.02; 410.10; 410.11; 410.12; 410.20; 410.21; 410.22; 410.30; 410.31; 410.32; 410.40; 410.41; 410.42; 410.50; 410.51; 410.52; 410.60; 410.61; 410.62; 410.70; 410.71; 410.72; 410.80; 410.81; 410.82; 410.90; 410.91; 410.92
Anemia	280.0; 280.1; 280.8; 280.9; 281.0; 281.1; 281.2; 281.3; 281.4; 281.8; 281.9; 285.21; 285.29; 285.8; 285.9
CKD	585.1; 585.2; 585.3; 585.4; 585.5; 585.6; 585.9
COPD	490; 491.0; 491.1; 491.20; 491.21; 491.22; 491.8; 491.9; 492.0; 492.8; 493.00; 493.01; 493.02; 493.10; 493.11; 493.12; 493.20; 493.21; 493.22; 493.81; 493.82; 493.90; 493.91; 493.92; 494.0; 494.1; 495.0; 495.1; 495.2; 495.3; 495.4; 495.5; 495.6; 495.7; 495.8; 495.9; 496
Cancer	140.3; 140.4; 140.0; 140.1; 140.9; 140.8; 140.5; 140.6; 141.9; 141.3; 141.0; 141.2; 141.8; 141.4; 141.5; 141.6; 141.1; 142.1; 142.2; 142.8; 142.9; 142.0; 143.0; 143.9; 143.8; 143.1; 144.9; 144.0; 144.8; 144.1; 145.5; 145.1; 145.2; 145.3; 145.0; 145.9; 145.6; 145.8; 145.4; 146.9; 146.5; 146.6; 146.7; 146.4; 146.0; 146.1; 146.2; 146.8; 146.3; 147.9; 147.1; 147.0; 147.8; 147.2; 147.3; 148.0; 148.9; 148.8; 148.1; 148.2; 148.3; 149.0; 149.9; 149.1; 149.8; 150.4; 150.5; 150.8; 150.9; 150.2; 150.3; 150.0; 150.1; 151.0; 151.2; 151.5; 151.3; 151.4; 151.1; 151.6; 151.8; 151.9; 152.1; 152.9; 152.2; 152.3; 152.8; 152.0; 153.5; 153.6;

	153.1; 153.0; 153.9; 153.2; 153.7; 153.8; 153.3; 153.4; 154.1; 154.2; 154.8; 154.0; 154.3; 155.0; 155.2; 155.1; 156.2; 156.8; 156.0; 156.1; 156.9; 157.1; 157.0; 157.8; 157.3; 157.9; 157.4; 157.2; 158.9; 158.0; 158.8; 159.1; 159.0; 159.8; 159.9; 160.0; 160.8; 160.2; 160.9; 160.3; 160.1; 160.5; 160.4; 161.0; 161.8; 161.1; 161.9; 161.2; 161.3; 162.2; 162.3; 162.5; 162.0; 162.8; 162.4; 162.9; 163.9; 163.8; 163.0; 163.1; 164.1; 164.9; 164.2; 164.3; 164.8; 164.0; 165.8; 165.9; 165.0; 170.5; 170.9; 170.6; 170.7; 170.8; 170.0; 170.1; 170.2; 170.3; 170.4; 171.7; 171.8; 171.2; 171.0; 171.6; 171.3; 171.9; 171.5; 171.4; 172.3; 172.4; 172.0; 172.1; 172.2; 172.7; 172.5; 172.6; 172.8; 172.9; 173.02; 173.20; 173.12; 173.09; 173.10; 173.11; 173.22; 173.19; 173.51; 173.21; 173.32; 173.39; 173.40; 173.41; 173.42; 173.49; 173.50; 173.80; 173.81; 173.52; 173.29; 173.30; 173.31; 173.00; 173.01; 173.62; 173.69; 173.70; 173.71; 173.72; 173.79; 173.91; 173.82; 173.89; 173.90; 173.59; 173.92; 173.99; 173.60; 173.61; 174.1; 174.8; 174.5; 174.2; 174.3; 174.4; 174.6; 174.9; 174.0; 175.0; 175.9; 176.2; 176.4; 176.5; 176.8; 176.9; 176.3; 176.0; 176.1; 179; 180.9; 180.8; 180.0; 180.1; 181; 182.0; 182.1; 182.8; 183.8; 183.9; 183.5; 183.2; 183.3; 183.0; 183.4; 184.1; 184.2; 184.0; 184.9; 184.8; 184.3; 184.4; 185; 186.9; 186.0; 187.1; 187.2; 187.3; 187.4; 187.5; 187.6; 187.7; 187.8; 187.9; 188.3; 188.5; 188.6; 188.7; 188.4; 188.0; 188.9; 188.2; 188.8; 188.1; 189.8; 189.0; 189.4; 189.9; 189.2; 189.3; 189.1; 190.4; 190.2; 190.0;

	190.1; 190.7; 190.3; 190.5; 190.6; 190.8; 190.9; 191.2; 191.3; 191.6; 191.7; 191.4; 191.5; 191.0; 191.1; 191.8; 191.9; 192.0; 192.1; 192.9; 192.2; 192.3; 192.8; 193; 194.0; 194.1; 194.3; 194.4; 194.5; 194.6; 194.8; 194.9; 195.8; 195.4; 195.1; 195.3; 195.5; 195.2; 195.0; 196.9; 196.2; 196.3; 196.0; 196.1; 196.8; 196.5; 196.6; 197.0; 197.1; 197.4; 197.5; 197.2; 197.3; 197.8; 197.6; 197.7; 198.0; 198.3; 198.4; 198.5; 198.6; 198.7; 198.81; 198.82; 198.89; 198.2; 198.1; 199.0; 199.1; 199.2; 200.28; 200.30; 200.27; 200.33; 200.34; 200.21; 200.22; 200.23; 200.24; 200.25; 200.26; 200.42; 200.43; 200.44; 200.31; 200.32; 200.47; 200.48; 200.35; 200.36; 200.37; 200.38; 200.40; 200.41; 200.56; 200.57; 200.58; 200.60; 200.61; 200.62; 200.63; 200.64; 200.65; 200.66; 200.67; 200.68; 200.70; 200.71; 200.72; 200.73; 200.74; 200.75; 200.76; 200.77; 200.78; 200.80; 200.81; 200.82; 200.83; 200.84; 200.85; 200.86; 200.87; 200.88; 200.45; 200.46; 200.00; 200.01; 200.50; 200.51; 200.52; 200.53; 200.54; 200.55; 200.10; 200.11; 200.12; 200.13; 200.14; 200.15; 200.16; 200.17; 200.18; 200.20; 200.04; 200.05; 200.06; 200.07; 200.08; 200.02; 200.03; 201.92; 201.93; 201.96; 201.97; 201.94; 201.95; 201.76; 201.77; 201.78; 201.90; 201.91; 201.51; 201.52; 201.00; 201.01; 201.02; 201.03; 201.98; 201.44; 201.45; 201.46; 201.47; 201.48; 201.50; 201.11; 201.12; 201.13; 201.14; 201.15; 201.16; 201.17; 201.18; 201.20; 201.21; 201.22; 201.23; 201.24; 201.25; 201.26; 201.27; 201.28; 201.40;

	201.41; 201.42; 201.43; 201.04; 201.05; 201.06; 201.07; 201.08; 201.10; 201.65; 201.66; 201.67; 201.53; 201.54; 201.55; 201.56; 201.73; 201.74; 201.75; 201.60; 201.61; 201.62; 201.63; 201.64; 201.72; 201.68; 201.70; 201.71; 201.57; 201.58; 202.08; 202.00; 202.03; 202.04; 202.05; 202.06; 202.07; 202.37; 202.38; 202.40; 202.41; 202.42; 202.43; 202.01; 202.02; 202.32; 202.33; 202.34; 202.35; 202.36; 202.52; 202.53; 202.10; 202.11; 202.12; 202.13; 202.44; 202.45; 202.46; 202.47; 202.48; 202.50; 202.51; 202.22; 202.23; 202.24; 202.25; 202.26; 202.27; 202.28; 202.30; 202.31; 202.75; 202.76; 202.77; 202.78; 202.80; 202.81; 202.82; 202.83; 202.84; 202.85; 202.86; 202.87; 202.88; 202.90; 202.91; 202.92; 202.93; 202.94; 202.95; 202.96; 202.54; 202.55; 202.56; 202.57; 202.14; 202.15; 202.16; 202.17; 202.18; 202.20; 202.21; 202.65; 202.66; 202.67; 202.68; 202.70; 202.71; 202.72; 202.73; 202.74; 202.60; 202.61; 202.62; 202.63; 202.64; 202.97; 202.98; 202.58; 203.00; 203.82; 203.81; 203.10; 203.11; 203.01; 203.02; 203.12; 203.80; 204.02; 204.10; 204.01; 204.00; 204.21; 204.11; 204.12; 204.20; 204.91; 204.81; 204.82; 204.90; 204.92; 204.22; 204.80; 205.10; 205.02; 205.91; 205.00; 205.01; 205.20; 205.21; 205.11; 205.12; 205.31; 205.32; 205.80; 205.81; 205.82; 205.90; 205.22; 205.92; 205.30; 206.81; 206.00; 206.01; 206.82; 206.10; 206.11; 206.12; 206.20; 206.21; 206.22; 206.80; 206.90; 206.91; 206.92; 206.02; 207.81; 207.00; 207.10;

	207.11; 207.12; 207.20; 207.21; 207.22; 207.80; 207.82; 207.02; 207.01; 208.82; 208.01; 208.02; 208.00; 208.12; 208.20; 208.21; 208.22; 208.80; 208.81; 208.92; 208.10; 208.90; 208.91; 208.11; 209.41; 209.51; 209.42; 209.43; 209.50; 209.55; 209.56; 209.57; 209.60; 209.61; 209.62; 209.63; 209.64; 209.65; 209.66; 209.67; 209.69; 209.70; 209.71; 209.72; 209.73; 209.74; 209.75; 209.79; 209.22; 209.23; 209.24; 209.25; 209.26; 209.27; 209.29; 209.30; 209.31; 209.32; 209.33; 209.34; 209.35; 209.36; 209.40; 209.02; 209.03; 209.10; 209.11; 209.12; 209.52; 209.53; 209.54; 209.16; 209.17; 209.20; 209.00; 209.01; 209.13; 209.14; 209.15; 209.21; 235.9; 235.1; 235.0; 235.5; 235.2; 235.3; 235.4; 235.6; 235.7; 235.8; 236.0; 236.2; 236.3; 236.4; 236.1; 236.6; 236.7; 236.90; 236.5; 236.99; 236.91; 237.2; 237.3; 237.1; 237.0; 237.6; 237.70; 237.4; 237.5; 237.73; 237.79; 237.71; 237.72; 237.9; 238.2; 238.3; 238.0; 238.1; 238.8; 238.9; 238.4; 238.5; 238.6; 238.71; 238.72; 238.73; 238.74; 238.75; 238.76; 238.77; 238.79; 239.6; 239.9; 239.7; 239.81; 239.2; 239.3; 239.4; 239.89; 239.5; 239.0; 239.1
Diabetes	250.00; 250.01; 250.02; 250.03; 250.10; 250.11; 250.12; 250.13; 250.20; 250.21; 250.22; 250.23; 250.30; 250.31; 250.32; 250.33; 250.40; 250.41; 250.42; 250.43; 250.50; 250.51; 250.52; 250.53; 250.60; 250.61; 250.62; 250.63; 250.70; 250.71; 250.72; 250.73; 250.80; 250.81; 250.82; 250.83; 250.90; 250.91; 250.92; 250.93

HF	428.0; 428.1; 428.20; 428.21; 428.22; 428.23; 428.30; 428.31; 428.32; 428.33; 428.40; 428.41; 428.42; 428.43; 428.9
HIV	042
Hyperlipidemia	272.0; 272.1; 272.2; 272.3; 272.4; 272.5; 272.6; 272.7; 272.8; 272.9
Hypertension	401.0; 401.1; 401.9; 402.00; 402.01; 402.10; 402.11; 402.90; 402.91; 403.00; 403.01; 403.10; 403.11; 403.90; 403.91; 404.00; 404.01; 404.02; 404.03; 404.10; 404.11; 404.12; 404.13; 404.90; 404.91; 404.92; 404.93; 405.01; 405.09; 405.11; 405.19; 405.91; 405.99
Parkinson	332.0; 332.1
Sleep Apnea	327.23
Stroke	433.01; 433.11; 433.21; 433.31; 433.81; 433.91; 434.01; 434.11; 434.91
TIA	434.01; 434.11; 434.91

Supplementary Table 2. ICD-10 Codes for Cause of Death

Major cardiovascular diseases	I00-I78
Diseases of heart	I00-I09, I11, I13, I20-I51
Hypertensive heart disease with or without renal disease	I11,I13
Ischemic heart diseases	I20-I25
Other diseases of heart	I00-I09,I26-I51
Essential (primary) hypertension and hypertensive renal disease	I10,I12
Cerebrovascular diseases	I60-I69
Atherosclerosis	I70
Other diseases of circulatory system	I71-I78

Supplementary Table 3. Number of First HF Discharges of patients with history of hypertension by Year

Year	Counts	Age at 1st HF
2000	3,303	74.4
2001	3,300	74.5
2002	3,540	74.2
2003	3,566	74.7
2004	3,300	74.5
2005	3,276	75.3
2006	3,084	75.2
2007	3,065	75.3
2008	3,465	74.9
2009	3,510	75.5
2010	3,576	75.1
2011	3,474	74.7
2012	3,408	75.2
2013	3,623	74.9
2014	3,651	74.9
TOTAL	51,141	

Abbreviations: HF, heart failure

Supplementary Table 4. All-Cause Readmissions (%)

HF Discharge Year	30-Day	90-Day	180-Day	1-Year
2000	18.2	33.12	44.96	59.13
2001	18.12	33.61	45.79	59.18
2002	18.79	34.66	45.93	59.15
2003	18.65	33.62	45.20	57.91
2004	17.97	33.73	45.55	58.30
2005	19.78	35.20	47.22	59.43
2006	19.75	34.79	45.43	58.11
2007	20.65	36.87	47.93	62.12
2008	22.45	39.39	50.82	63.61
2009	23.16	39.46	50.48	63.28
2010	22.12	37.98	50.84	62.81
2011	24.06	40.10	52.73	65.00
2012	22.07	39.82	51.26	63.44
2013	21.81	38.59	51.34	63.46
2014	22.27	38.87	51.66	63.65
Sum	20.70	36.71	48.55	61.29

Supplementary Table 5. Heart Failure Readmissions (%)

HF Discharge Year	30-Day	90-Day	180-Day	1-Year
2000	5.24	10.35	14.90	21.04
2001	5.94	10.76	14.42	20.45
2002	5.54	10.90	15.56	22.15
2003	6.23	10.94	14.61	20.27
2004	5.97	11.42	16.18	21.94
2005	6.07	11.45	16.39	22.41
2006	6.81	12.42	16.73	21.40
2007	6.43	12.23	16.38	21.37
2008	7.19	12.81	17.00	22.28
2009	7.35	12.51	16.44	22.08
2010	6.15	11.27	15.38	20.97
2011	6.99	12.49	16.93	22.37
2012	6.13	11.50	15.73	20.89
2013	6.46	11.43	16.26	21.03
2014	6.55	11.80	15.89	20.84
Sum	6.34	11.61	15.91	21.43

Supplementary Table 6. All-Cause Death (%)

Heart Failure Discharge Year	30-Day	90-Day	180-Day	1-Year
2000	4.36	9.39	14.44	22.04
2001	4.15	8.79	13.70	20.85
2002	3.67	7.97	13.14	20.73
2003	4.49	10.54	15.20	22.55
2004	4.21	9.15	14.06	21.52
2005	4.30	9.86	13.98	21.70
2006	4.90	10.25	14.27	21.47
2007	3.95	9.33	14.00	20.69
2008	5.22	9.84	14.57	21.24
2009	5.04	11.00	16.10	22.88
2010	4.53	10.10	14.77	21.67
2011	5.27	10.02	14.85	21.76
2012	4.31	9.83	14.88	21.80
2013	4.64	9.41	14.16	20.04
2014	4.57	9.26	13.72	20.05
Sum	4.51	9.65	14.40	21.40

Supplementary Table 7. Cardiovascular Death (%)

Heart Failure Discharge Year	30-Day	90-Day	180-Day	1-Year
2000	1.27	3.88	6.30	10.29
2001	1.45	3.45	6.06	9.42
2002	0.93	2.63	5.42	9.60
2003	1.54	4.04	6.28	9.98
2004	1.45	3.27	6.12	10.12
2005	1.31	3.85	5.62	9.37
2006	1.56	3.76	5.67	9.21
2007	1.11	3.43	5.77	8.78
2008	1.76	3.87	6.58	10.19
2009	1.57	4.33	7.07	10.66
2010	1.03	3.91	6.24	9.68
2011	1.58	3.34	5.79	9.33
2012	1.23	3.67	6.16	9.39
2013	1.21	3.28	5.80	8.80
2014	1.15	3.34	5.40	8.19
Sum	1.34	3.60	6.02	9.53

Supplementary Table 8. Cardiovascular Death

Risk Factor	30-Day	90-Day	180-Day	1-Year
Discharge year	1.016 (0.996, 1.036) 0.127	1.014 (1.002, 1.027) 0.027	1.007 (0.997, 1.016) 0.187	0.997 (0.989, 1.005) 0.460
Age (per 10 Years)	1.373 (1.265, 1.490) <0.001	1.501 (1.425, 1.580) <0.001	1.512 (1.453, 1.574) <0.001	1.499 (1.452, 1.548) <0.001
Sex (Male)	1.16 (0.987, 1.364) 0.072	1.144 (1.034, 1.266) 0.009	1.160 (1.071, 1.255) <0.001	1.166 (1.093, 1.244) <0.001
Race (Black)	0.66 (0.482, 0.904) 0.010	0.85 (0.710, 1.017) 0.075	0.837 (0.729, 0.961) 0.012	0.923 (0.828, 1.029) 0.149
Race (Other)	0.717 (0.515, 0.998) 0.049	0.900 (0.745, 1.087) 0.273	0.869 (0.748, 1.008) 0.063	0.903 (0.801, 1.017) 0.093
Non-Hispanic vs. Hispanic	1.350 (0.909, 2.004) 0.137	1.439 (1.129, 1.835) 0.003	1.541 (1.273, 1.866) <0.001	1.383 (1.194, 1.604) <0.001
Unknown vs. Hispanic	1.510 (0.951, 2.397) 0.080	1.498 (1.124, 1.995) 0.006	1.470 (1.170, 1.846) <0.001	1.298 (1.085, 1.553) <0.001
Commercial Insurance vs. Medicare	0.745 (0.584, 0.949) 0.017	0.841 (0.727, 0.973) 0.020	0.830 (0.740, 0.929) 0.001	0.811 (0.740, 0.889) <0.001
Medicaid/Self-Pay/Other vs. Medicare	0.818 (0.449, 1.492) 0.512	0.998 (0.705, 1.412) 0.989	1.147 (0.889, 1.479) 0.291	1.026 (0.834, 1.262) 0.810
Length of Stay	1.626 (1.491, 1.773) <0.001	1.545 (1.463, 1.631) <0.001	1.396 (1.337, 1.457) <0.001	1.296 (1.252, 1.342) <0.001
AFib/AFlutter	1.022 (0.865, 1.207) 0.795	1.140 (1.029, 1.262) 0.012	1.075 (0.992, 1.166) 0.079	1.040 (0.973, 1.111) 0.252
AMI	1.260 (1.011, 1.569) 0.040	1.361 (1.190, 1.556) <0.001	1.317 (1.184, 1.465) <0.001	1.331 (1.221, 1.452) <0.001
Anemia	1.071 (0.898, 1.277) 0.446	1.022 (0.916, 1.141) 0.698	1.124 (1.032, 1.224) 0.007	1.142 (1.065, 1.225) <0.001
CKD	1.001 (0.761, 1.318) 0.992	1.030 (0.870, 1.220) 0.728	1.126 (0.989, 1.282) 0.074	1.088 (0.977, 1.211) 0.125

COPD	1.030 (0.863, 1.231) 0.742	1.082 (0.970, 1.208) 0.157	1.055 (0.967, 1.150) 0.230	1.109 (1.034, 1.189) 0.004
Diabetes	0.854 (0.719, 1.015) 0.073	0.891 (0.801, 0.991) 0.033	0.912 (0.839, 0.991) 0.029	0.918 (0.858, 0.982) 0.012
Hyperlipidemia	0.870 (0.734, 1.031) 0.108	0.886 (0.797, 0.984) 0.024	0.870 (0.801, 0.945) <0.001	0.915 (0.856, 0.979) 0.010
Sleep Apnea	0.946 (0.463, 1.933) 0.880	0.790 (0.490, 1.275) 0.334	0.696 (0.470, 1.030) 0.070	0.824 (0.616, 1.103) 0.193
Parkinson	0.456 (0.216, 0.965) 0.040	0.898 (0.639, 1.261) 0.533	0.943 (0.726, 1.225) 0.661	0.984 (0.797, 1.214) 0.887
Stroke	1.997 (1.018, 3.916) 0.044	1.864 (1.198, 2.902) 0.006	1.820 (1.270, 2.608) 0.001	1.734 (1.278, 2.352) <0.001
TIA	0.621 (0.304, 1.270) 0.192	0.621 (0.389, 0.992) 0.046	0.669 (0.458, 0.978) 0.038	0.698 (0.506, 0.962) 0.028
Hosp No Cath Lab vs. Cath Lab	0.992 (0.814, 1.208) 0.933	0.953 (0.842, 1.078) 0.443	0.981 (0.890, 1.081) 0.697	1.009 (0.931, 1.093) 0.835
Hosp Inner City Area vs. Urban	0.905 (0.684, 1.199) 0.488	1.035 (0.878, 1.220) 0.680	1.096 (0.964, 1.245) 0.161	1.013 (0.912, 1.124) 0.814
Hosp Rural Area vs. Urban	0.905 (0.676, 1.213) 0.505	0.869 (0.723, 1.043) 0.132	0.879 (0.762, 1.014) 0.078	0.892 (0.796, 0.999) 0.048
Hosp Suburb Area vs. Urban	1.119 (0.920, 1.360) 0.260	1.059 (0.938, 1.196) 0.356	1.059 (0.963, 1.166) 0.238	1.029 (0.952, 1.112) 0.476
Hosp Non-Teaching vs. Teaching	1.197 (0.981, 1.460) 0.076	1.158 (1.022, 1.311) 0.021	1.108 (1.005, 1.222) 0.040	1.135 (1.047, 1.230) 0.002

Abbreviations: AMI, acute myocardial infarction; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; AFib, atrial fibrillation; Aflutter, atrial flutter; TIA, transient ischemic attack

Readmission and mortality among heart failure patients with history of hypertension in a statewide database

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ABSTRACT

Objectives: To examine the temporal trends in readmission and mortality of heart failure (HF) patients with history of hypertension.

Methods: This study includes 51,141 patients with history of hypertension who were discharged with a first diagnosis of HF between January 1, 2000 and December 31, 2014. Data were obtained from the Myocardial Infarction Data Acquisition System (MIDAS), a statewide database of all hospitalizations for cardiovascular disease in New Jersey. The temporal trends of mortality, rates of HF specific readmission and all-cause readmissions up to one year after discharge were examined using multivariable logistic regression. The difference in all-cause mortality at 3 years between patients who were readmitted compared to those who were not readmitted at one year was examined.

Results: The number of patients with history of hypertension and HF remained unchanged during the study period. Male gender, black race, comorbidities and admission to non-teaching hospitals were predictors of HF readmission and CV mortality ($p<0.05$ for all). Readmission rate for any cause increased during the study period ($p<0.001$) while rates of HF readmissions and mortality remained relatively unchanged. Patients that had been readmitted within a year exhibited a significantly higher 3-year mortality ($p<0.001$).

Conclusions: CV mortality among HF patients with history of hypertension did not change significantly between 2000 and 2014, while the rates of all-cause readmission increased. Patients who were readmitted had higher 3-year mortality ($p<0.001$) than those who were not.

Keywords: heart failure, readmissions, mortality, hypertension**,** population-based study

Abbreviations: HF, heart failure; MIDAS, Myocardial Infarction Data Acquisition System; ICD-CM, international classification of diseases-clinical modification; CKD, chronic kidney disease; AMI, acute myocardial infarction; PCI, percutaneous coronary intervention; CV, cardiovascular; COPD, chronic obstructive pulmonary disease; LOS, length of stay; HRRP, hospital readmission reduction program

INTRODUCTION

Hypertension frequently antedates the development of heart failure (HF). In the Framingham Heart Study, 91% of all newly diagnosed HF patients had a documented history of hypertension [1]. Heart failure is the most common reason for hospital admission in adults and is associated with impaired quality of life, high mortality, financial burden, and frequent readmissions [2-3]. The US health care expenditures on HF reached $30.7 billion between 2011-2014 [4] and this number is anticipated to increase to almost $70 billion by 2030 [5]. Previous studies have addressed the issues of the incidence, outcomes, and time-trends of HF readmissions of patients with history of hypertension. Most of these reports were either from single-center intervention trials, were review papers and meta-analyses, used different methodologies and did not include follow-up for more than 30 days. Also, these papers did not examine secular changes or did not report on the long-term mortality of patients who were readmitted as compared to those who were not [3,6-15].

The purpose of this study is to describe the incidence, time-trends, and outcomes of HF readmissions in a population-based cohort of 51,141 HF patients with history of hypertension from 2000 to 2014 using the Myocardial Infarction Data Acquisition System (MIDAS) in New Jersey [16-18]. We also examined differences in mortality among patients who were readmitted versus patients who were not.

METHODS

Data sources

The MIDAS database was used to obtain information on patients with history of hypertension who were hospitalized for HF. MIDAS captures the dates of admission and discharge,

demographics, insurance type, reason for admission, and selected comorbid conditions. International Classification of Diseases-Clinical Modification (ICD-9-CM) in acute care non-federal hospitals in New Jersey from 2000 to 2014, was used for the identification of hypertension, HF and comorbid conditions. The ICD-9 codes used to identify the above variables are shown in Suppl Table 1. Hospital characteristics included hospital location (inner city, urban, rural, suburban), teaching status (teaching versus non-teaching) and availability of invasive or interventional procedures. The date and cause of death were obtained from New Jersey Death Registration files. We used "The Link King" [19], an automated public record linkage and consolidation software that, in a report of 500,000 linked records chosen at random and referred for blinded clerical review, had a positive predictive value of 96.1% and a sensitivity of 96.7% [20].

Patients with history of hypertension who were hospitalized for HF were identified with ICD-9-CM primary discharge diagnosis code 428.xx (reason for admission). The cause of death was recorded using the ICD-10-CM codes (Suppl Table 2).

The information in MIDAS has been validated as correct in 98.8% for vital status at discharge and demographics [21]. Study patients were 18 years or older and history of hypertension who were discharged alive after a first admission for HF. Of the 51,141 patients who fulfilled the inclusion criteria, 1756 (3.4%) were excluded from the statistical analysis because of missing values. Patients with history of cancer and/or HIV were not included in this study.

Study variables

Study variables included patient demographics, comorbid conditions, hospital characteristics [teaching/non-teaching, geographic location, facilities for percutaneous coronary intervention (PCI)], length of stay (LOS), and insurance type.

Outcomes – Statistics

Outcomes were CV and all-cause death, readmission for HF, and all-cause readmission at 30 days, 90 days, 180 days and 1 year. Multivariable logistic regression models adjusted for demographics, hospital characteristics, LOS, and the comorbid conditions listed above were developed. The time trends of the endpoints were examined using linear models. The effect of readmission on all-cause death at 3-years in HF patients with history of hypertension who were readmitted as compared to those who were not readmitted was studied using logistic regression. This study was approved by the Rutgers Health Sciences Institutional Review Board.

RESULTS

Outcomes at 30 days, 90 days, 180 days and at 1 year following discharge

The number of patients with history of hypertension and a first diagnosis of HF as the reason for admission who were discharged alive by year of admission ranged from 3065 to 3655 per year (Table 1). The number of patients with history of hypertension and HF remained unchanged during the study period (Figure 1). All-cause readmissions demonstrated a statistically significant positive slope by 0.478 percent per year (95% CI: 0.317 to 0.639, p<0,001) while linear trends of 1-year outcomes with respect to HF readmissions, all-cause mortality and CV mortality there were not altered considerably (Figure 2). At one year, more than sixty per cent of

the patients were readmitted (61.3%) and more than one-fifth (21.4%) died. About one half of the study patients were admitted to teaching hospitals (47.8%), while 43.8% of the patients were admitted to hospitals with PCI facilities. Over one sixth (17.9%) of the patients were admitted to hospitals located in an inner city, 24.1% to hospitals in urban areas, 42.5% in suburb locations, and 12.1% to hospitals in rural areas (Table 2).

All-cause and HF readmissions are presented in Suppl Tables 3 and 4. All-cause readmission rates at 30 days and 1 year were 20.7% and 61.29%, respectively (Suppl Table 3), whereas HF-specific readmission occurred for 6.34% of the patients at 30-days and 21.43% at one year (Suppl Table 4). The unadjusted 30-day readmission rates as well as all-cause and CV death remained relatively stable (Suppl Tables 3, 5 and 6).

Predictors of higher all-cause readmission at one year were LOS (odds ratio [OR]: 1.04, 95% CI: 1.02 to 1.06), anemia (OR: 1.20, 95% CI: 1.15 to 1.26), atrial fibrillation/flutter (OR: 1.08, 95% CI: 1.04 to 1.13), CKD (OR: 1.35, 95% CI: 1.26 to 1.45), COPD (OR: 1.25, 95% CI: 1.20 to 1.30), diabetes (OR: 1.23, 95% CI: 1.18 to 1.28), hyperlipidemia (OR: 1.14, 95% CI: 1.10 to 1.19), and admission to a non-teaching hospital (OR: 1.10, 95% CI: 1.05 to 1.15) ($p<0.001$ for all, Table 3). Patients with commercial insurance were less likely to be readmitted (OR: 0.88, 95% CI: 0.84 to 0.93, $p<0.001$) and male gender was associated with better outcomes (OR: 0.94, 95% CI: 0.90 to 0.98, $p<0.001$)

Logistic regression identified black race (OR: 1.25, 95% CI: 1.17 to 1.33), stroke (OR: 1.54, 95% CI: 1.2 to 1.96), history of AMI (OR: 1.12, 95% CI: 1.05 to 1.19), COPD (OR: 1.09, 95% CI: 1.03 to 1.14), diabetes (OR: 1.21, 95% CI: 1.15 to 1.26), as important predictors of HF

readmission for HF at one year of follow-up, (p<0.001 for all, Table 4). A similar effect of insurance type was observed for HF readmissions (OR: 0.92, 95% CI: 0.87 to 0.97, p<0.001).

Logistic regression identified age per 10 years (OR: 1.57, 95% CI: 1.53 to 1.60), male gender (OR: 1.18, 95% CI: 1.12 to 1.23), LOS (OR: 1.46, 95% CI: 1.43 to 1.50), anemia (OR: 1.30, 95% CI: 1.23 to 1.36), history of AMI (OR: 1.23, 95% CI: 1.15 to 1.31), COPD (OR: 1.23, 95% CI: 1.17 to 1.29), CKD (OR: 1.37, 95% CI: 1.27 to 1.48), stroke (OR: 1.53, 95% CI: 1.19 to 1.96), and Parkinson's disease (OR: 1.34, 95% CI: 1.15 to 1.55), as important predictors of all-cause mortality at one year (p<0.001 for all, Table 5). Commercial insurance was associated with lower all-cause mortality (OR: 0.82, 95% CI: 0.78 to 0.86, p<0.001).

Logistic regression identified age (OR: 1.50 per 10 years, 95% CI: 1.45 to 1.55), male gender (OR: 1.17, 95% CI: 1.09 to 1.24), LOS (OR: 1.30, 95% CI: 1.25 to 1.34), anemia (OR: 1.14, 95% CI: 1.07 to 1.23), history of AMI (OR: 1.33, 95% CI: 1.22 to 1.45), COPD (OR: 1.11, 95% CI: 1.03 to 1.19), stroke (OR: 1.73, 95% CI: 1.28 to 2.35), and admission to a non-teaching hospital (OR: 1.14, 95% CI: 1.05 to 1.23), as important predictors of CV mortality at one year, (p<0.001 for all, Suppl Tables 7 and 8).

The most common causes of readmission at one year, present in at least 1% of the patients with history of hypertension, were grouped into 13 categories and are presented in Figure 3. HF was the most common reason for readmission followed by respiratory, heart, and CKD. In the aggregate, all reasons for readmission with rates below 1% accounted for 21.7% of the total. Approximately 4 out of 10 patients (38.7%) discharged following an admission for HF were not readmitted within a year.

There were no significant trends for all-cause and CV mortality. Using a logistic regression model with $\log_2$ of number of days to readmission as a predictor of one-year all-cause mortality, we estimated an odds ratio of 0.816 (95% CI: 0.805 to 0.827, p<0,001).

All-cause mortality of patients with history of hypertension who were readmitted as compared to those who were not readmitted

All-cause 3-year mortality among HF patients discharged alive was significantly higher in patients who were readmitted within one year from the index hospitalization (OR: 1.31, 95% CI: 1.26 to 1.36, p< 0.001). The 3-year all-cause mortality adjusted for all covariates remained significantly higher in patients who were readmitted vs those not readmitted (OR: 1.49, 95% CI: 1.45 to 1.54, p< 0.001). Figure 4 shows the odds ratios for all-cause mortality at 3 years from the index HF admission comparing patients readmitted versus those who were not readmitted by reason for readmission. Readmission for AMI, CKD, acute infection, or cerebrovascular accident increased the risk of 3-year mortality.

Figure 5 presents the adjusted 3-year mortality rates of HF patients re-hospitalized for various reasons. Logistic regression determined history of AMI (OR: 2.2, 95% CI: 1.91 to 2.55), infections (OR: 2.01, 95% CI: 1.74 to 2.32), CKD (OR: 1.91, 95% CI: 1.73 to 2.11), stroke (OR: 1.83, 95% CI: 1.49 to 2.26), and patients with respiratory disease (OR: 1.29, 95% CI: 1.19 to 1.41, p< 0.001 for all), as predictors of mortality within 3 years following discharge among patients with a first diagnosis of HF. The effect of these comorbid conditions on all-cause mortality is higher than that observed in a mixed cohort of HF patients with and without history of hypertension (prior AMI OR:1.42 95% CI: 1.26 to 1.60, infection-related readmission

OR:1.32 95% CI: 1.17to 1.49, history of kidney disease OR:1.20 95% CI: 1.10 to 1.31, stroke OR:1.15 95% CI: 0.97 to 1.35, respiratory disease was non-significant, respectively).

DISCUSSION

In this study, the number of HF readmissions of patients with history of hypertension remained relatively stable. All-cause readmissions increased significantly during the period of observation ($p<0.001$) while all-cause and CV mortality remained unchanged. This has been attributed to a decreased case fatality of AMI [22].

More than sixty per cent of the patients were readmitted within a year and patients with longer LOS, anemia, CKD, COPD were more likely to be readmitted. Patients with history of hypertension who were readmitted had higher 3-year all-cause mortality as compared to those who were not readmitted. The findings of Fernandez-Gasso et al. on 30-day HF readmissions are similar to ours [23]. Also, Bottle et al. reported that HF, ischemic heart disease, cardiac dysrhythmias, and diseases of the respiratory or genitourinary system were common reasons for readmission, findings congruent with the results of this report [24]. Likewise, Davis et al., in an all-payer analysis of HF hospitalizations, found that comorbid conditions similar to those described in this paper were associated with higher rate of readmission up to 30 days [25]. Gulea et al. reported that HF patients with COPD were at significantly higher risk of readmission, a finding similar to the present study [26].

Our observation that certain comorbid conditions helped to predict mortality has been documented by previous investigators. Fonarow et al. observed that patients with ischemia and those with worsening renal function had a higher mortality at follow-up [27]. In OPTIMIZE-HF, high systolic blood pressure was an independent predictor of morbidity and mortality, similar to

the findings of the present study. Investigators from both the PRESERVE and OPTIMIZE-HF studies highlighted that kidney disease is a strong predictor of mortality, an association also reported by Lawson et al. in a UK national study [27-29].

Ruigomez et al., reporting on 3516 patients in The Health Improvement Network primary care database, also found higher mortality among patients readmitted for HF [30]. A publication from Alon et al. among 9355 HF patients with infection-related readmissions reported increased mortality over a 10-year period [31]. Similarly, results from the GREAT registry indicated a higher 90-day risk of death after a hospitalization for acute infection [32]. Similar to our findings of increased mortality with infections, are the findings of Panhwar et al. of an association between influenza and increased inpatient morbidity and mortality [33]. Gerber et al. reported that HF markedly increases the risk of death after MI regardless of ejection fraction [34].

In the present study, LOS was associated with higher all-cause readmission and all-cause mortality, similar to the results of Khan et al. from the EVEREST Trial [35]. Samsky et al. in their recent study on trends in readmission and LOS for hospitalized patients with HF in Canada and the U.S., reported similar results with respect to 30-day readmission rates. The baseline characteristics of the U.S. cohort are similar with respect to demographics of this study [5]. It appears that being longer inpatient did not result in lowering the chance of readmission and death by stabilizing and better treating the patients. Rather, the reason for the higher case fatality and rate of readmission was probably due to a more advanced staged of HF in these patients. Samsky et al. did not report on readmission up to one year and did not examine mortality [5]. This limitation of the study by Samsky et al. is emphasized by Su et al. who stated that the 30-day readmission rate is not an optimal standard for HF management [36]. The effects of

comorbid conditions and race observed by these authors are congruent to our results [36]. Su et al. recommend that in the future, process indicators will provide additional benefits in the evaluation and treatment of HF, as also reported by Fischer et al. and Barbayannis et al. [37,38]. These studies reported findings similar to ours although they have the drawbacks outlined in introduction e.g. most were from a single-center, were reviews or meta-analyses, did not include follow-up for more than 30 days, did not examine secular changes and did not report on the long-term mortality of patients who were readmitted.

Bradley et al. and Bilchick et al. reported that specific strategies employed before discharge resulted in decreased readmission rates and expense [39,40], while Van Spall et al. reported that implementation of a patient-centered transitional care model did not improve clinical outcomes [41]. However, the results from a review from Delgado-Passler indicated that a telemanagement program after hospital discharge would result in less frequent rehospitalizations and improvement of the patient's quality of life [42]. Van spall also noticed Nurse home visits and Disease management clinics reduce all-cause mortality and all-cause readmissions after hospitalization for HF [43].

The time range of this study did not include enough data to examine the effect of the Hospital Readmission Reduction Program (HRRP) since the data collection ended in 2014. Khera and colleagues, reported that the announcement or implementation of the HRRP was not associated with an increase in in-hospital or post-discharge mortality [44]. This was attributed to the fact that physicians did not adopt strategies that specifically deferred admissions [45]. Conversely, Wadhera et al., studying 7.9 million Medicare beneficiaries with HF, MI, and pneumonia published that the HRRP announcement and implementation was associated with an increase in post-discharge mortality [46].

An important limitation of this study is that confounders such as clinical and laboratory data including hemodynamic status, left ventricular function, physical findings, and hospital programs designed to decrease the rate of readmissions are not included in the dataset. Also, information on medications used during hospitalization or prescribed at discharge is not available. It is possible that the use of different medication classes (e.g. diuretics, β-blockers, or calcium channel blockers) were associated with different rates of readmission and mortality. However, the present study has significant strengths, including that the data are derived from a statewide database, and an assessment of trends over a 15-year period. Also, this New Jersey statewide database represents a population of approximately 9 million residents that has characteristics similar in ethnicity, age, household mean income, and education to the US a whole [47]. Moreover, health insurance coverage in NJ resembles that of the United States [48]. The large size of the study that includes every patient admitted with HF in New Jersey over a 15-year period draws from an unselected and unbiased population gives additional credence to our conclusions.

In summary, this study of 51,141 patients with history of hypertension who were discharged alive with a diagnosis of HF between 2000 and 2014 shows that the number of patients admitted for the first time for HF did not change during the 15 years of the study, that more than sixty per cent of these patients were readmitted within one year, and that patients who were readmitted had a significantly higher all-cause mortality over a three-year period than those who were not readmitted. This provides an opportunity to improve the prognosis of HF in patients with history of hypertension by preventing and managing comorbidities and appropriate discharge planning.

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