Trends in the magnitude of chronic conditions in patients hospitalized with a first acute myocardial infarction

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Abstract

Background: Among adults with heart disease, there is a high prevalence of concomitant chronic medical conditions. We studied patients with a first acute myocardial infarction to describe: sample population characteristics; trends of the most prevalent pairs of chronic conditions; and differences in hospital management according to burden of these morbidities.

Methods and Results: Patients (n = 1,564) hospitalized with an incident AMI at the 3 major medical centers in central Massachusetts during 2005, 2011, and 2015 comprised the study population. Hospital medical records were reviewed to identify 11 more prevalent chronic conditions. The median age of this population was 68 years and 56% were men. The median number of previously diagnosed chronic conditions was 2. Patients hospitalized during 2015 were more likely to be younger than those hospitalized in the earliest study cohorts. The most common pairs of chronic conditions for those hospitalized in 2005 were: anemia-chronic kidney disease (31%), chronic kidney disease-heart failure (30%), and stroke-atrial fibrillation (27%). Among patients hospitalized during 2011, chronic kidney disease-heart failure (29%), hypertension-hyperlipidemia (27%), and hypertension-diabetes (27%) were the most common pairs whereas hypertension-hyperlipidemia (43%), diabetes-heart failure (30%), and chronic kidney disease-diabetes (23%) were the most frequent pairs recorded in 2015. There was a significant decrease in the odds of undergoing cardiac catheterization and a percutaneous coronary intervention in those with higher chronic disease burden in the most recent as compared to earliest study years.

Conclusions: Our findings highlight the magnitude of chronic conditions in patients with AMI and the challenges of caring for this vulnerable population.

Introduction

The prevalence of multiple chronic diseases in patients hospitalized with an acute myocardial infarction (AMI) has become increasingly common.[1] Patients with multiple chronic conditions (MCCs) are at substantial risk for disability, death, and poor quality of life, and account for a disproportionate share of U.S. health care related expenditures.[2–7] The clinical management of persons hospitalized

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with an AMI and MCCs is particularly challenging, due in part to their high risk for adverse events, as well as the need for complex and tailored therapeutic regimens.[8] Despite the high prevalence of MCCs in patients hospitalized for an AMI, there are relatively limited contemporary data describing the magnitude, characteristics, and hospital management of patients hospitalized with an incident AMI and MCCs. Moreover, data remain lacking about trends in the most frequent pairs of chronic conditions that complicate the management of these patients from a more generalizable community-based perspective.[9–12] The objectives of this observational study were to describe and compare the demographic and clinical characteristics of individuals hospitalized with an initial AMI in 2005, 2011, and 2015 as part of a community-based coronary disease surveillance study. We further examined and compared the most prevalent pairs of chronic conditions and the in-hospital clinical management of those with a high (≥ 3) vs. low (≤ 2) number of chronic conditions during the 3 years under study.

Methods

The Worcester Heart Attack Study is an ongoing population-based investigation that is examining long-term trends in the clinical epidemiology of AMI among residents of the Worcester, Massachusetts (MA), metropolitan area hospitalized at all medical centers in central MA on an approximate biennial basis.[13–17]

Computerized medical record printouts of residents of central MA admitted to the three major hospitals that treat patients with acute coronary disease in the Worcester metropolitan area with possible AMI (International Classification of Disease (ICD) 9 codes 410–414, and 786.5) were identified. Cases of possible AMI were independently validated using predefined criteria for AMI, including diagnoses of ST segment elevation myocardial infarction (STEMI) and non-ST segment elevation myocardial infarction (NSTEMI).[18,19] The present study was restricted to patients with an initial AMI because we were interested in describing the clinical features and the presence of other chronic conditions in those with a first clinical manifestation of underlying coronary atherosclerosis. Inasmuch, patients with a history of previously diagnosed AMI (n = 829) based on the review of hospital medical records were excluded from the present study. This study was approved by the Institutional Review Board at the University of Massachusetts Medical School.

Trained nurses and physicians abstracted information on patient's demographic and clinical characteristics. These characteristics included patient's age, sex, race/ethnicity, hospital length of stay, and previously diagnosed chronic conditions including anemia, atrial fibrillation, asthma/chronic pulmonary disease, chronic kidney disease, depression, diabetes, heart failure, hyperlipidemia, hypertension, peripheral vascular disease, and stroke. These 11 chronic conditions were selected based on their high prevalence in our study cohort and because they occurred at a frequency $\geq 3\%$.[20–22] Data on the receipt of three coronary diagnostic and interventional procedures [cardiac catheterization, percutaneous coronary intervention (PCI), and coronary artery bypass graft surgery (CABG)] during hospitalization, and evidence-based pharmacotherapies, namely angiotensin converting inhibitors (ACE-I)/angiotensin receptor blockers (ARBs), aspirin, beta blockers, and lipid lowering agents were also obtained. The 3 study periods of 2005, 2011, and 2015 were selected for purposes of examining decade long trends in patient's demographic and clinical characteristics and prevalent pairs of chronic conditions in our study cohorts.

We compared differences in various demographic and clinical characteristics between patients hospitalized during our 3 study years using chi square tests for categorical variables and the ANOVA test for continuous variables. We calculated a tetrachoric correlation, a type of correlation applicable when both observed variables are dichotomous,[23] to determine the most prevalent pairs of morbidities among all the possible combinations of the 11 chronic conditions examined in the present study.

We further stratified our study population into two groups for purposes of examining the impact of high (≥ 3) versus low (≤ 2) burden of chronic conditions in the clinical management of patients hospitalized with an AMI. We used two conditions as a cut point because it was the median number of chronic conditions observed in our study population. Logistic regression models (unadjusted and adjusted for age and sex) were utilized to estimate the odds of receiving cardiac related medications and diagnostic/interventional procedures according to the presence of chronic conditions during the index hospitalization for AMI across the 3 study years.

Results

A total of 1,564 residents of central MA were hospitalized with an independently validated first AMI at all three major medical centers in central Massachusetts during the period under study. The median age of this patient population was 68 years and 56% were men. The average number of previously diagnosed chronic conditions in this population was 2.7 while the median number was 2.0. The average and median number of chronic conditions in this patient population did not change during the years under study.

Patients hospitalized during 2015 were more likely to be younger and male but slightly less likely to present with a NSTEMI than those hospitalized in 2005 (Table 1).

Patients hospitalized during the 2 most recent study years of 2011 and 2015 were more likely to have been previously diagnosed with chronic kidney disease, diabetes, and hyperlipidemia as compared with those hospitalized during 2005. On the other hand, those hospitalized during the most recent study years were less likely to have

Table 1. Characteristics of patients hospitalized with an initial acute myocardial infarction according to study year.

Characteristic	2005 (n = 590)	2011 (n = 519)	2015 (n = 455)
Age (years) (median)	73	66	64*
Male (%)	51.7	59.2	58.7*
White race	91.9	90.8	84.2*
NSTEMI	63.9	65.5	60.7
Do not resuscitate orders	24.1	17.0	13.2**
Medical history (%)			
Anemia	11.5	11.2	7.3
Atrial fibrillation	11.9	11.8	10.6
Chronic kidney disease	17.5	17.7	20.7
Chronic obstructive pulmonary disease/asthma	13.6	14.1	9.9
Depression	16.3	13.5	13.9
Diabetes	28.3	32.8	33.2
Heart failure	19.7	12.7	12.8**
Hyperlipidemia	52.2	67.4	66.2**
Hypertension	72.0	69.4	72.3
Peripheral vascular disease	17.6	17.7	12.3*
Stroke	9.2	6.4	5.3
Cumulative number of comorbidities (%)			
Any 2 or fewer	51.2	50.3	50.3
Any 3	20.3	19.7	20.0
Any 4 or more	28.5	30.1	29.7

* p value <0.05. ** p value <0.001. NSTEMI: Non-ST-elevation myocardial infarction.

been previously diagnosed with anemia, heart failure, and stroke than those hospitalized during 2005 (Table 1). The cumulative burden of chronic conditions was relatively similar across the 3 study years, with almost one in five individuals presenting with three chronic conditions and 1/3 of the study sample presenting with four or more chronic conditions.

The most common pairs of chronic conditions for those hospitalized with a first AMI in 2005 were: anemia-chronic kidney disease, chronic kidney disease-heart failure, and stroke-atrial fibrillation (31%, 30%, and 27% of patients, respectively) (Figure 1). For those hospitalized during 2011, the most common pairs of chronic conditions were: chronic kidney disease-heart failure (29%) hypertension-hyperlipidemia (27%) and hypertension-diabetes (27%) (Figure 2). Among those hospitalized during the most recent study year of 2015, the most common pairs were: hypertension-hyperlipidemia, diabetes-heart failure, and chronic kidney disease-diabetes (43%, 30%, and 23%, respectively) (Figure 3).

Overall, the proportion of patients who received any of the diagnostic/interventional cardiac procedures was significantly higher during 2015 as compared with 2005 and 2011, with the exception of the receipt of a percutaneous coronary intervention (PCI) that remained unchanged over time (Table 2).

The proportion of patients who received lipid lowering medication and aspirin was significantly higher during 2015 as compared with the earliest study years, whereas there was a marked decline in the use of ACE inhibitors/ARBs in the most recent patient cohort (Table 2).

The proportion of patients who received any of the four cardiac related medications was similar between those who presented with two or fewer chronic conditions as compared to those with three or more conditions in 2005, 2011, and 2015. Unadjusted and adjusted regression analyses were performed to more systematically examine trends in hospital clinical management practices (Table 3). Results of the unadjusted analysis showed no differences in the odds of receiving any of the four examined cardiac related medications according to the presence of chronic conditions during the years under study. These results essentially remained unchanged after adjusting for age and sex.

The proportion of patients who underwent a cardiac catheterization and a PCI was significantly lower in those who presented with 3 or more previously diagnosed conditions as compared to those who presented with 2 or fewer conditions during the years under study (Table 4). Results of the unadjusted analysis showed a 60% and 76% decreased in the odds of undergoing a cardiac catheterization in those with 3 or more conditions as compared with those who presented with 2 or fewer conditions during 2011 and 2015, respectively. After adjusting for age and sex, the odds of undergoing a cardiac catheterization remained lower in those with 3 or more conditions as compared to those with 2 conditions or fewer, with an approximate 54% reduced likelihood in 2005 and 60% reduced likelihood in 2015 (Table 4).

Similar trends were found in the odds of receiving a PCI. Results of the unadjusted analysis showed a 60% decreased odds of undergoing a PCI in those with three or more chronic conditions as compared with those who presented with two or fewer previously diagnosed chronic conditions. After adjusting for age and sex, the odds of receiving a PCI remained lower in those with three or more conditions as compared to those with two conditions or fewer, with a 40% reduced likelihood in 2005 and 70% reduced likelihood in 2015 (Table 4).

We also examined trends in the odds of undergoing a CABG during the index hospitalization for AMI; although there was a slight increase in the odds of undergoing a CABG during the most recent study years according to the presence of MCCs, these findings were not statistically significant (Table 4).

Due to some potential differences in the characteristics of patients with and without do not resuscitate orders (DNR) at the time of their hospitalization for AMI; we also performed a sensitivity analysis including DNR as a covariate when we examined the association of receiving cardiac related medications and diagnostic/interventional procedures according to the presence of chronic conditions. No differences were noted in our observed estimates of receiving any of the cardiac related medications and
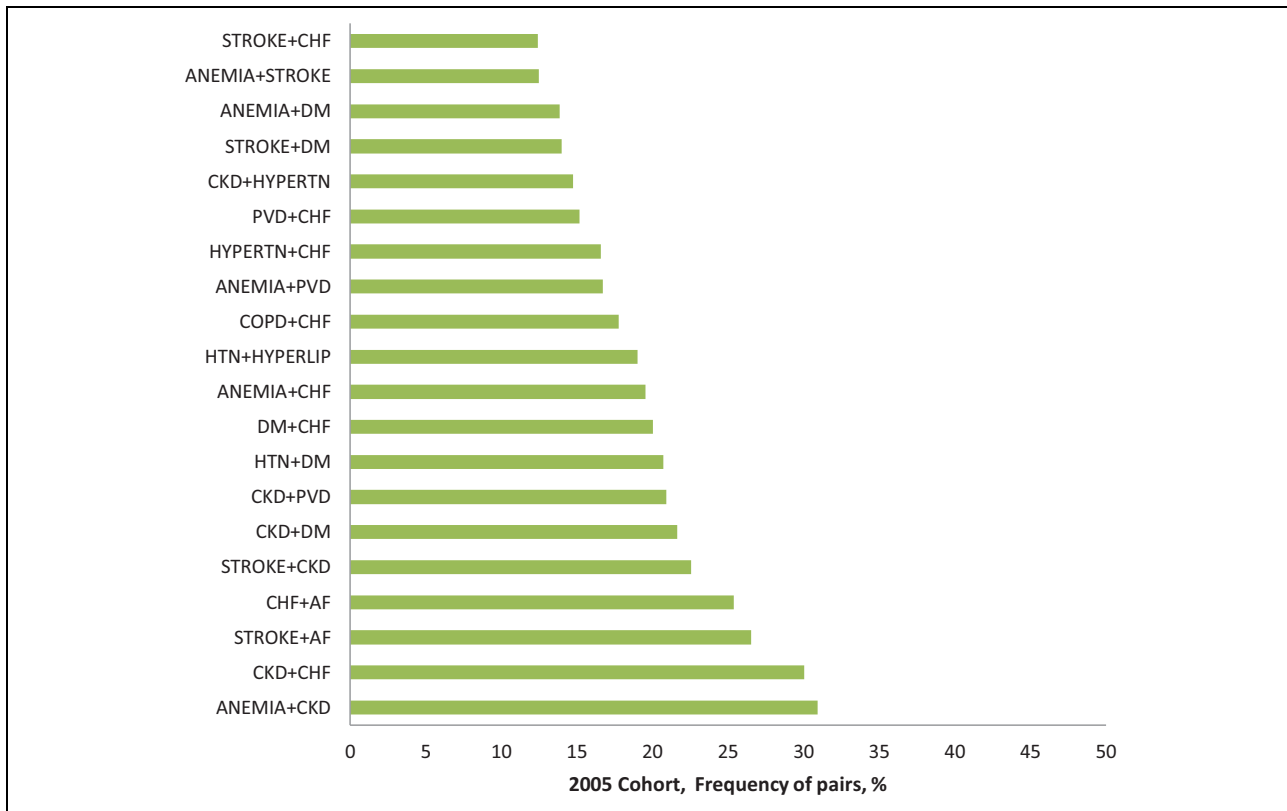
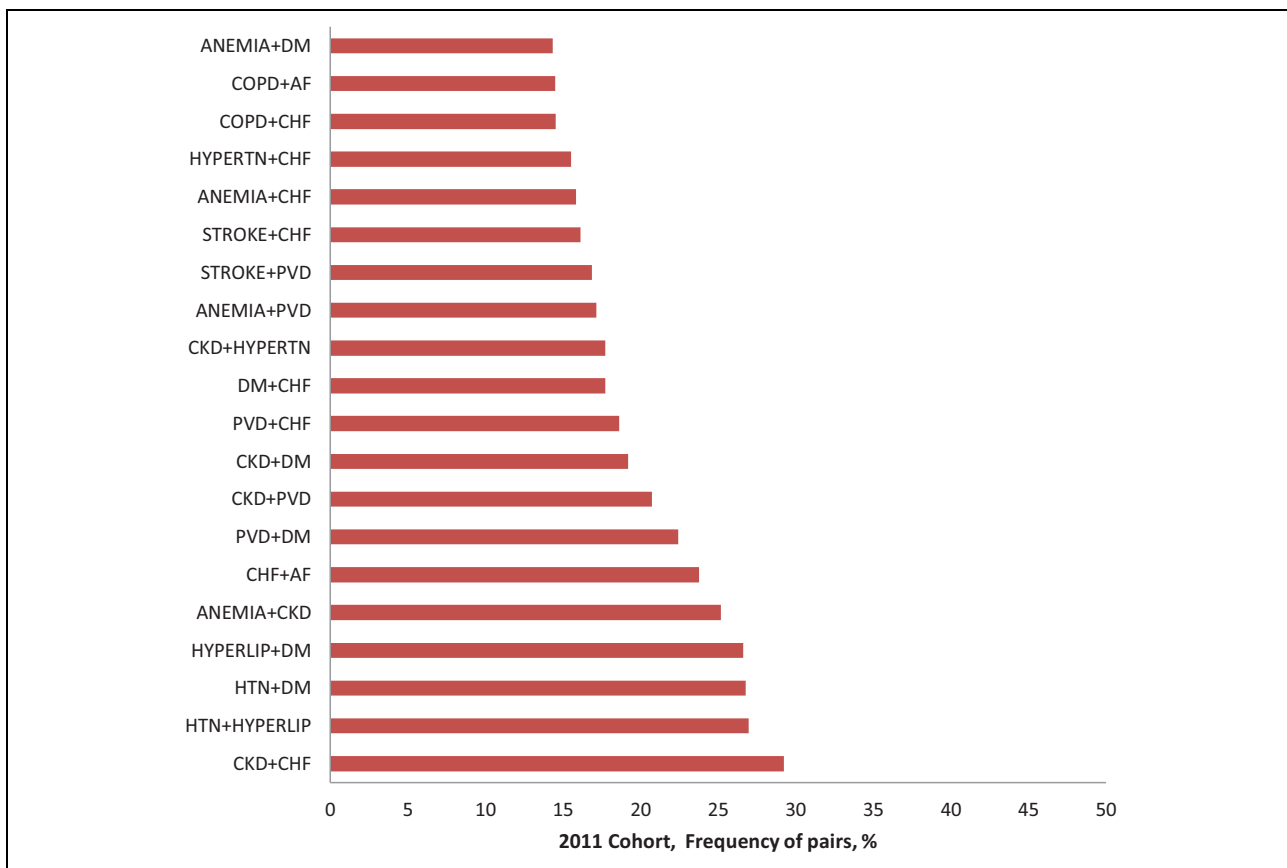**Figure 1.** Frequency of pairs of chronic conditions during 2005.

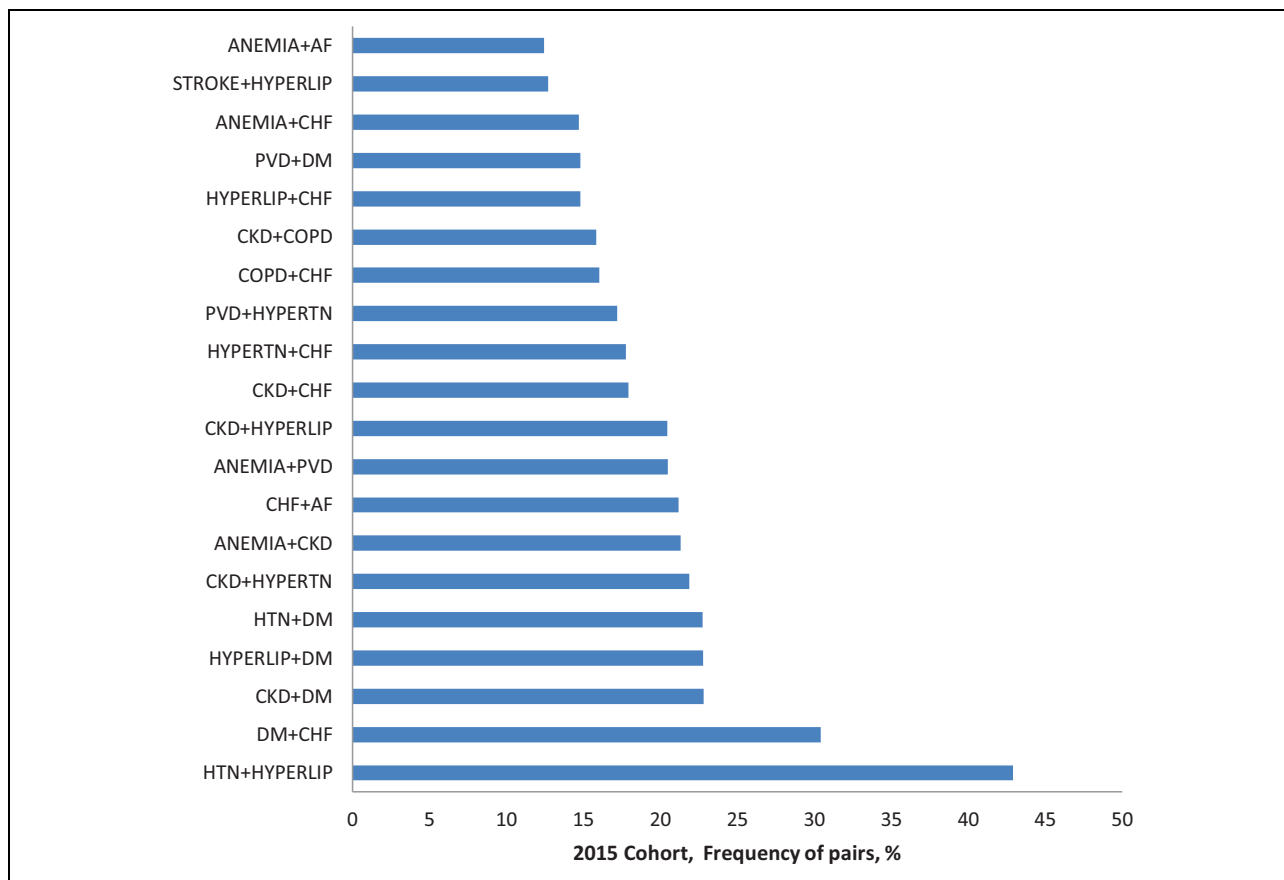**Figure 2.** Frequency of pairs of chronic conditions during 2011.

Figure 3. Frequency of pairs of chronic conditions during 2015.

Table 2. Hospital clinical management according to study year.

Intervention and clinical management during hospitalization	2005 (n = 590)%	2011 (n = 519)%	2015 (n = 455)%
Cardiac catheterization	68.5	69.6	80.0
Percutaneous coronary intervention	53.6	52.4	55.4
Coronary artery bypass surgery	1.7	6.2	7.5
Clinical management			
Lipid lowering agents	64.1	87.3	92.1**
Aspirin	94.4	94.8	96.0
ACE/ARBS	70.2	66.3	55.6**
Beta-blocker agent	94.6	91.7	90.8*

* p value <0.05. ** p value <0.001.
ACE/ARBS: angiotensin converting enzyme inhibitors/Angiotensin II receptor blockers.

undergoing diagnostic/interventional procedures that we examined after adjusting for patient's DNR status.

Discussion

In this population-based study of adults hospitalized with a first AMI at all three major medical centers serving residents of the Worcester metropolitan area, we found that the most prevalent pairs of previously diagnosed chronic conditions in 2005 were anemia/chronic kidney disease, chronic kidney disease/heart failure, and stroke/atrial fibrillation. On the other hand, during the most recent study year of 2015, the most frequent pairs of chronic conditions were hypertension/hyperlipidemia, diabetes/heart failure, and chronic kidney disease/diabetes. While we did not observe any changes in the hospital prescribing of effective cardiac medications according to burden of chronic conditions during the years under study, we observed a significant decrease in the odds of undergoing a cardiac catheterization and a PCI according to the burden of chronic conditions in the most recent years under study.

Our findings suggest that individuals hospitalized for a first AMI during the most recent study years tended to be younger as compared with those hospitalized in 2005. We observed a higher prevalence of diabetes and chronic kidney disease as well as a lower prevalence of anemia and stroke in the most recent as compared with earliest study cohort.

Our findings are similar to the results of other investigations. In a study of more than 30,000 patients (mean age: 64 years) with an acute coronary syndrome in the nationwide AMIS Plus registry in Switzerland between 2002 and

Table 3. Frequency and likelihood of receiving cardiac related medication according to chronic conditions and study year.

	2005			2011			2015		
	Received, %	OR	a OR	Received, %	OR	a OR	Received, %	OR	a OR
ACE/ARBS									
<2 MCCs	70.2			66.7			52.8		
≥3 MCCs	70.1	1.00 (0.70; 1.42)	1.10 (0.75; 1.60)	65.9	0.97 (0.67; 1.39)	1.11 (0.74; 1.68)	58.4*	1.25 (0.87; 1.82)	1.42 (0.93; 2.15)
Aspirin									
<2 MCCs	95.4			96.2			97.8		
≥3 MCCs	93.4	0.69 (0.34; 1.40)	0.94 (0.45; 1.96)	93.4	0.56 (0.25; 1.26)	0.96 (0.36; 2.56)	94.3	0.37 (0.13; 1.04)	0.71 (0.19; 2.65)
Beta-Blocker									
<2 MCCs	94.4			93.9			92.1		
≥3 MCCs	94.8	1.09 (0.53; 2.22)	1.26 (0.59; 2.67)	89.5	0.59 (0.29; 1.06)	1.08 (0.51; 2.25)	89.4*	0.72 (0.38; 1.36)	1.08 (0.51; 2.27)
Lipid Lowering									
<2 MCCs	64.2			87.4			93.0**		
≥3 MCCs	63.9	0.98 (0.70; 1.38)	1.08 (0.76; 1.55)	87.2	0.99 (0.59; 1.65)	1.64 (0.87; 3.08)	91.2**	0.77 (0.39; 1.53)	1.01 (0.46; 2.23)

*p value <0.05. **p value <0.001 OR: odds ratio a OR: adjusted Odds ratio. Adjusted models for age and sex.
ACE/ARBS: angiotensin converting enzyme inhibitors/Angiotensin II receptor blockers; MCCs: Multiple chronic conditions.

Table 4. Frequency and likelihood of receiving diagnostic interventions according to chronic conditions and study year.

	2005			2011			2015		
	Received, %	OR	a OR	Received, %	OR	a OR	Received, %	OR	a OR
Catheterization									
<2 MCCs	78.8			78.9			90.4		
≥3 MCCs	57.6	0.37 (0.25;0.53)	0.64 (0.42;0.96)	60.1	0.40 (0.27;0.59)	0.46 (0.28;0.76)	69.5	0.24 (0.14;0.41)	0.41 (0.21;0.77)
PCI									
<2 MCCs	65.2			65.1			69.4		
≥3 MCCs	41.3	0.38 (0.27;0.52)	0.61 (0.42;0.88)	39.5	0.35 (0.25;0.50)	0.42 (0.28;0.65)	41.2	0.31 (0.21;0.45)	0.43 (0.28;0.45)
CABG									
<2 MCCs	5.0			4.6			7.0		
≥3 MCCs	3.4	0.48 (0.19;1.19)	0.45 (0.17;1.18)	7.8	1.74 (0.83;3.65)	1.82 (0.83;3.96)	8.0	1.15 (0.57;2.32)	1.43 (0.67;3.64)

*p value <0.05. ** p value <0.001. OR: odds ratio. a OR: adjusted Odds ratio. Adjusted models for age and sex. PCI: Percutaneous coronary intervention; CABG: Coronary Artery Bypass Grafting; MCCs: Multiple chronic conditions.

2012, two of the most prevalent conditions in this population were diabetes (15%) and chronic kidney disease (7%).[24] In a study of more than 5,000 patients hospitalized with AMI in Spain between 2003 and 2009, the most prevalent chronic conditions were hypertension (49%), diabetes (38%), heart failure (25%), and kidney disease (11%).[25]

These collective findings suggest that patients hospitalized with a first AMI present with a high prevalence of diabetes and chronic kidney disease, which clinicians involved in the diagnosis, clinical management, and education of these individuals need to be aware of. Health care providers need to work together with patients and their caregivers to ensure adherence to their complex treatment regimens and in the implementation of lifestyle interventions to help this vulnerable population to manage their diverse chronic conditions.

Our findings suggest that the most prevalent pairs of chronic conditions during the most recent year under study were hypertension/hyperlipidemia, diabetes/heart failure, and chronic kidney disease/diabetes.

Few studies have examined the frequency of particular pairs of chronic conditions in patients hospitalized with an AMI. One of the few studies that described the frequency of pairs of chronic conditions in these patients was a study in Melbourne, Australia that included approximately 1,500 older adults (mean age: 79 years) hospitalized with a non-ST-elevation AMI.[26] Diabetes and renal disease (13%) co-existed frequently in this patient population. Somewhat different pairs of frequently occurring chronic conditions were described in the Transitions, Risks, and Actions in Coronary Events Center for Outcomes Research and Education study, which longitudinally followed 2,174 adults hospitalized with an acute coronary syndrome at five medical centers in MA and GA.[22] The most frequently diagnosed pairs of chronic conditions found in this cohort at the time of baseline study enrollment were hyperlipidemia and hypertension, diabetes and hypertension, and diabetes and hyperlipidemia (60%, 28%, and 26%, respectively).

Differences in the most common chronic conditions in patients hospitalized with acute coronary disease are likely explained by differences in the socio-demographic and clinical characteristics of the respective study populations, periods under study, lack of consensus in terms of the chronic conditions included in these investigations, and working definitions used to classify the comorbidities under study. Monitoring trends in the frequency of various chronic conditions among patients hospitalized with an AMI is of continued importance to guide health care providers in clinical decision-making and in the management of these complex patients.

In contrast to our proposed hypotheses, we failed to observe differences in the prescribing of effective cardiac medications according to the frequency of chronic conditions during the years under study; however, we found a significant decrease in the odds of undergoing a cardiac catheterization and a PCI according to the magnitude of chronic conditions during the decade long period under study. We also observed a slight increase in the odds of undergoing a CABG during the most recent study years according to the number of chronic conditions present, consistent with the findings from other investigations.[7,24,27,28]

In a study of nearly 3,000 patients with AMI treated at 53 hospitals in Ontario, Canada between 1999 and 2003, the number of pre-existing conditions was inversely associated with the receipt of coronary reperfusion therapy.[27] These investigators suggested that a possible explanation for this treatment-risk paradox may have been due to physicians being generally averse to providing more aggressive treatments to patients with MCCs because they perceive these interventions as either risky or futile due to the complexity and overall fragility of the patient's health status.[27] Data from the AMIS Plus registry found that patients with MCCs were less likely to have received coronary reperfusion therapy (47%) as compared to patients without these underlying conditions (79%).[24] Other possible explanations for the observed lower likelihood of undergoing a cardiac catheterization and a PCI in the present study among those with higher burden of MCCs could be attributed to the clinical characteristics of the patient populations studied, such as a higher prevalence of diabetes and chronic kidney disease.[29]

Our findings, in combination with prior study findings, emphasize the importance of developing comprehensive management guidelines specifically tailored to hospitalized AMI patients with MCCs given the increasing prevalence of this vulnerable population and their high risk of developing adverse outcomes. Moreover, future studies should investigate the use of more aggressive early detection measures and/or treatment focus on particular prevalent pairs of comorbidities that might place individuals at higher risk of death or that might worsen prognoses.

Importantly, efforts to reduce these risks are particularly challenging as most clinical practice guidelines do not take comorbidity pairs into account in providing treatment recommendations.[30] Caution is required in applying established clinical practice guidelines to the care of individuals with AMI and other chronic conditions since this could result in undesirable effects and less than optimal outcomes including adverse interactions between drugs and various conditions.[8] The paucity of relevant clinical evidence worsens an all-too common quandary faced by health care providers in making clinical decisions regarding the care of individuals with AMI. Physicians struggle with the dilemma of using treatments that may not be beneficial and that could cause harm to these complex patients versus denying effective treatments to patients at high risk for dying who could benefit from more aggressive management.[8,30]

The strengths of the present study include its community-based design and its large sample of patients hospitalized with an independently validated first AMI over a decade long period. Several limitations, however, need to be acknowledged in the interpretation of the present findings. Since our study population only included patients who had been hospitalized in central MA, extrapolation of our findings to those who reside in other geographic areas should be considered with regard to the generalizability of our population and healthcare environment. Second, since the majority of study patients were white, the generalizability of our findings to other race/ethnic groups may be limited. We did not have available community-based data on the primary and secondary risk factors for AMI in younger individuals in central MA population and how the conventional and novel predisposing factors may have changed over time. Lastly, there is always the potential for unmeasured confounding in an observational study since we did not have information available on several patient-associated characteristics, such as income, education, severity of chronic disease, or time since diagnosis of the chronic conditions under study

The findings of the present investigation highlight the magnitude of a variety of chronic conditions in patients hospitalized with an AMI. Since some chronic conditions, such as diabetes and chronic kidney disease, were more frequently diagnosed in patients hospitalized during the most recent study years, health care providers should be increasingly aware of the most prevalent pairs of chronic conditions in order to improve the in-hospital management of the most vulnerable groups. Our findings highlight the importance of developing future guidelines and clinical trials to focus on the management, in-hospital, and long-term outcomes of individuals with MCCs.

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