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Research paper

Prevalence, predictors, and in-hospital outcomes of ST-elevation myocardial infarction among young adults without traditional cardiovascular risk factors in the United States

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ABSTRACT

Background: Standard Modifiable Cardiovascular Risk Factors (SMuRF) such as hypertension, diabetes mellitus, hypercholesterolemia, and smoking have long been established in the etiology of atherosclerotic disease. Studies suggest that patients without any of these risk factors (SMuRF-less) who present with ST-elevation myocardial infarction have worse outcomes.

Methods: The National Inpatient Sample databases (2016 to 2020) was queried to identify STEMI admissions as a principal diagnosis using ICD 10 codes. The study population aged 18 to 45 years were divided into cohorts of SMuRF and SMuRF-less based on the presence of ≥1 risk factor (hypertension, diabetes mellitus, hyperlipidemia, and smoking), and in-hospital outcomes were compared.

Results: 41,990 patients were identified as the final study population. 38,495 patients were identified as SMuRF, and 3495 patients were SMuRF-less. Compared to SMuRF patients, SMuRF-less patients are more likely to be females (23.2 % vs. 21.2 %), have congestive heart failure (16.6 % vs. 13.7 %, $p < 0.01$) but less likely to have obesity (13.7 % vs 28.0 %, $p < 0.01$) In evaluating outcomes, SMuRF-less patients had higher adjusted in-hospital mortality (aOR 2.6, CI 1.5–4.2, $p < 0.01$), Cardiogenic shock (aOR 1.8, CI 1.3–2.5, $p < 0.01$), acute kidney injury (aOR 1.4, CI 1.0–1.9, $p = 0.02$), and Extramembrane Corporeal Oxygenation (aOR 4.1, CI 1.1–15.1, $p = 0.03$). Fluid and electrolyte abnormalities was an independent predictor of mortality among SMuRF-less patients (aOR 3.82, CI 1.3–11.2, $p < 0.01$).

Conclusion: Young patients who present with STEMI and have no traditional cardiovascular risk factors have worse in-hospital outcomes. Further research is needed to evaluate the impact of non-traditional risk factors on acute myocardial infarction.

1. Introduction

Coronary artery disease is the leading cause of death in the United States [1]. With a prevalence of over 7 %, it is estimated to affect over 16 million Americans aged 20 and above. [1,2] ST-segment-elevation myocardial infarction (STEMI) is the most acute presentation of coronary artery disease, with ≈750,000 annual cases in the United States. [3] Hypertension, diabetes mellitus, hypercholesterolemia, and cigarette smoking, collectively considered standard modifiable cardiovascular risk factors (SMuRFs), are well-established and validated components of the Framingham cardiovascular risk score. [4–6] Current data suggest an increasing proportion of patients without SMuRFs (i.e., SMuRF-less) constitute 11–27 % of patients presenting with acute coronary syndrome (ACS). [7–10] In a meta-analysis of 1,285,722 patients from 15 studies presenting with ACS, the global proportion of SMuRF-less patients was 11.56 % with increasing prevalence since 2010. [11] Many studies have demonstrated that patients presenting with STEMI who are SMuRF-less have higher mortality and may have worse clinical

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outcomes when compared to patients with at least one SMuRF. [7,8,10,12–15] In a study of the Swedish myocardial infarction registry (SWEDEHEART), SMuRF-less patients had significantly higher all-cause mortality (hazard ratio 1·47 [95 % CI 1·37–1·57], $p < 0·0001$) with women being disproportionately affected when compared to patients with at least one SMuRF. Additionally, SMuRF-less patients were significantly less likely to receive angiotensin-converting enzymes (ACEIs) or angiotensin receptor blockers (ARB), statins, or beta-blockers at discharge [12]. While the exact reason for this observation remains unclear, insufficient understanding of the underlying mechanism of ACS in these patient populations may result in the delivery of suboptimal care. The Atherosclerosis Risk in Communities (ARIC) study showed that SMuRF-less patients presenting with ACS were 28 % less likely to undergo revascularization and had a significantly increasing trend in 28-day mortality. [16]

In many available studies evaluating the clinical outcomes of patients with and without SMuRFs presenting with ACS, the median age of SMuRF-less patients is between 60 and 72 years. [7,8,10,12] Young patients with ACS have a unique cardiovascular risk profile, yet there is a paucity of studies on their clinical characteristics and in-hospital outcomes when presenting with STEMI. The devastating impact of ACS on young patients carries significant health implications in addition to wasted potential and loss of life. We aimed to improve understanding of this underreported patient population while minimizing the confounding impact of age-associated multi-morbidity found in elderly patients.

2. Methodology

This retrospective study utilized the National Inpatient Sample (NIS) database from 2016 to 2020. The NIS contains deidentified elements such as patient demographics, principal diagnosis, secondary diagnosis, procedural diagnosis, and primary payer. It is a publicly available database derived from hospital billing data for State-wide organizations across the United States. It is managed by the Agency for Healthcare Research and Quality and was developed through a Federal-State-Industry partnership, providing valuable insight for decision-making at national, state, and community levels [17]. Over 7 million hospital stays are contained in the NIS each year, generating weighted estimates of 35 million hospitalizations across 48 States and the District of Columbia, accounting for over 97 % of the United States population. [17] Informed consent and Institutional Review Board were not required because NIS data are publicly available.

Using the *International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM)* codes, we identified patients admitted with STEMI as a principal diagnosis *(ICD-10-CM codes: I21.01, I21.2, I21.09, I21.1, I21.11, I21.19, I21.2, I21.21, I21.29, I23)*. To ensure that only patients with an index admission for STEMI were identified, we excluded patients with a history of coronary artery disease, myocardial infarction, Takotsubo cardiomyopathy, coronary artery bypass graft, and percutaneous coronary intervention. Patients with a history of cocaine use, spontaneous coronary dissection (SCAD), and those missing mortality data were also excluded from our study population. The final study population aged 18 to 45 years was divided into cohorts of SMuRFs and SMuRF-less based on the presence of ≥1 risk factor (hypertension, diabetes mellitus, hypercholesterolemia, and smoking). (Fig. 1).

The primary endpoint was the in-hospital mortality associated with STEMI among SMuRF-less patients compared to patients with at least one SMuRF. Secondary endpoints are STEMI-related complications, including acute heart failure, cardiogenic shock, cardiac arrest, stroke, acute kidney injury, ventricular fibrillation, use of vasopressors, intra-aortic balloon pump, and predictors of in-hospital mortality among SMuRF-less patients. Procedures and complications were identified using *ICD-10-CM* codes.

3. Statistical analysis

We analyzed and reported sociodemographic details such as age, sex, race/ethnicity, income, insurance, hospital characteristics, and co-morbidities for all patients. Co-morbidities were identified using the Charlson Co-morbidity Index (CCI), *ICD-10-CM* and *ICD-10-PCS* codes.

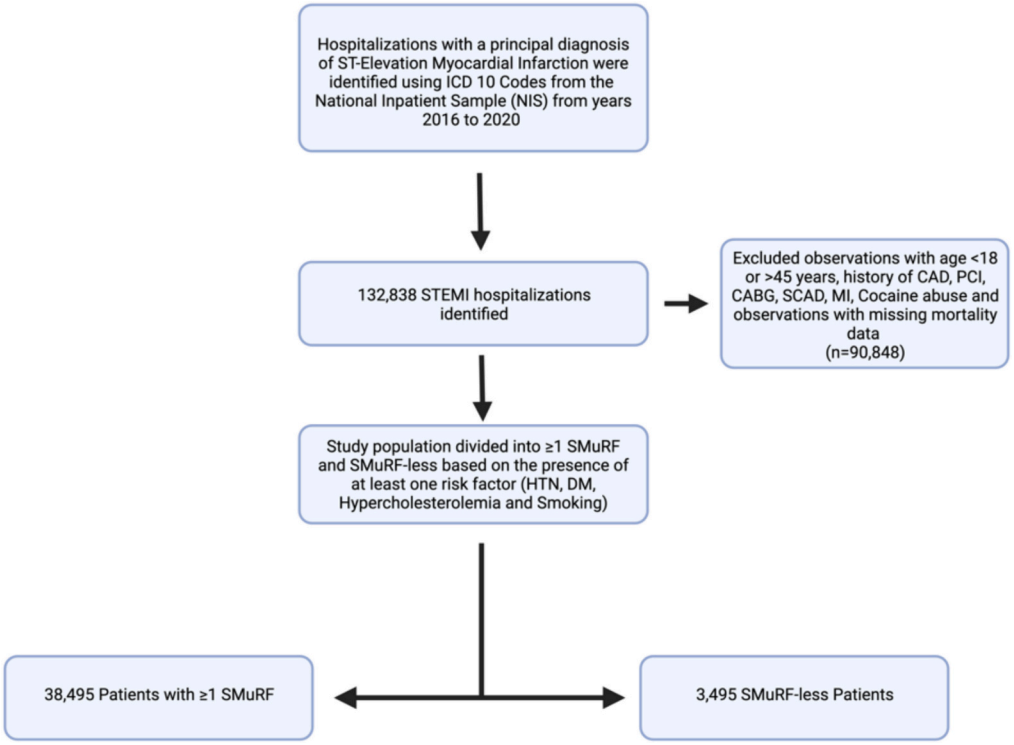

Fig. 1. Study flow diagram.

Categorical variables were expressed as frequencies with percentages and medians with interquartile range for continuous variables with skewed populations. Pearson chi-square test and Fisher exact test were used to compare categorical variables, and Wilcoxon rank sum test for continuous variables. After univariate analysis, all variables significantly associated with the outcome of interest with a *P*-value of <0.2 were used to build a multivariate regression model to control for all confounders. Based on literature review, other variables deemed important determinants of the outcomes of interest like race, ethnicity, income, and insurance, were included in the multivariate regression model [18–21]. Binary outcomes were compared using logistic regression, and continuous outcomes such as "length of stay" were compared using linear regression. Total hospitalization cost was adjusted for inflation using the 2016, 2017, 2018, 2019, and 2020 consumer price index. Our weighted linear and multivariable logistic regression was adjusted for patient-level information (age, sex, insurance, income, and family history of coronary artery disease) and hospital-level information (bed size, location, and region) and co-morbidities (Congestive heart failure, cardiomyopathy, atrial fibrillation, valvular disease, chronic obstructive coronary disease, obesity, anemia, paralysis, hypothyroidism, liver disease, solid tumor, coagulopathy, Fluid and electrolyte abnormalities, weight loss, psychoses, depression, chronic kidney disease, obstructive sleep apnea, alcohol use disorder, and Charlson Co-morbidity Index). Variables with missing observations are reported in the baseline characteristics (Table 1). Variables containing missing observations were minimal, such as race and ethnicity (4.0 %), income (1.8 %), and insurance status (0.2 %). Since the proportion of missing observations in each variable was <5 %, complete case analysis was used, and multiple imputations were not performed.

All statistical analyses were performed using Stata/MP 18.0 (StataCorp, College Station, Texas). Using svy commands, sampling weights, strata, and clusters were incorporated to generate U.S. national estimates. A 2-sided *P*-value < 0.05 was used as the threshold for statistical significance.

4. Results

A total of 41,990 weighted hospitalizations for STEMI were identified in the United States in the year 2016 to 2020. Of these patients, 8.3 % were SMuRF-less ($n = 3495$). SMuRF-less patients were younger, with a median age and interquartile range of 40 (34–43) years, compared to patients with at least one SMuRF, 41 (37–44) years ($P < 0.01$). SMuRF-less patients were also more likely to be females (23.2 % versus 21.2 %), of ethnic minority (32.6 % versus 28.6 %), and more likely to be in the highest income quartile (20.6 % versus 15.6 %). In comparing co-morbidities, SMuRF-less patients were less likely to have chronic obstructive bronchopulmonary disease (0.6 % versus 2.8 %), obesity (13.7 % versus 28.0 %), chronic kidney disease (1.1 % versus 4.3 %), and had less odds of family history of coronary artery disease (17.6 % versus 24.4 %). Additionally, SMuRF-less patients were more likely to have congestive heart failure (17.1 % versus 13.6 %), coagulopathy (7.7 % versus 3.1), liver disease (8.9 % versus 3.0 %), and weight loss (11.4 versus 0.5), all *P*-value < 0.01. There was no difference in COVID-19 infection rate among both cohorts. Refer to Table 1 for more details.

In evaluating in-hospital outcomes, SMuRF-less patients had higher in-hospital mortality (aOR, 2.6 [95 % CI, 1.5–4.2]; $P < 0.01$) and higher rates of STEMI-related complications including acute heart failure (aOR, 2.1 [95 % CI, 1.5–2.9]; $P < 0.01$), cardiogenic shock (aOR, 1.8 [95 % CI, 1.3–2.5]; $P < 0.01$), and cardiac arrest (aOR, 1.8 [95 % CI, 1.3–2.5]; $P < 0.01$), and acute kidney injury (aOR, 1.4 [95 % CI, 1.0–1.9]; $P < 0.01$). No statistically significant differences were observed in stroke rates among patients with and without SMuRFs (aOR, 1.8 [95 % CI, 0.8–3.8]; $P < 0.01$) and vasopressor use (aOR, 1.5 [95 % CI, 0.9–2.8]; $P = 0.15$). Notably, despite higher rates of in-hospital mortality and STEMI-related complications among SMuRF-less patients, they had lower rates of PCI (aOR, 0.7 [95 % CI, 0.6–0.8]; $P < 0.01$) and coronary artery bypass graft

Table 1
Sociodemographic Characteristics and Co-morbidities of Patients with and without Standard Modifiable Cardiovascular Risk Factors.

Variables	Patient characteristics		P-value
	SMuRF-less	≥1 SMuRF[a]	
Number, n (%)	n = 3495 (8.3)	*n* = 38,495 (91.6)	
Patient Characteristics			
Age, years, median (IQR)	40 (34–43)	41 (37–44)	<0.01
Sex (%)			0.07
Female	23.2	21.2	<0.01
Race (%)			<0.01
White	63.2	66.4	
Black	12.3	14.1	
Hispanic	14.5	10.2	
Asian or Pacific Islander	4.6	3.6	
Native American	1.2	0.7	
SMuRFs (%)			
Hypertension	–	61.9	
Hypercholesterolemia	–	60.4	
Smoking	–	67.5	
Diabetes Mellitus	–	28.4	
Co-morbidities (%)			
Congestive heart failure	16.6	13.7	0.03
Cardiomyopathy	5.7	3.7	0.07
Atrial fibrillation	3.3	3.3	0.98
Valvular disease	2.1	2.2	0.88
COPD[a]	0.6	2.8	<0.01
Obesity	13.7	28.0	<0.01
Anemia	8.6	7.5	0.30
Paralysis	0.9	0.4	0.03
Hypothyroidism	1.6	3.1	0.02
Liver disease	8.9	3.0	<0.01
Solid tumor	0.3	0.2	0.61
Coagulopathy	7.7	3.1	<0.01
Fluid and electrolyte abnormalities	21.9	17.4	<0.01
Weight loss	11.4	0.5	0.02
Chronic kidney disease	1.1	4.3	<0.01
Obstructive sleep apnea	2.9	5.9	<0.01
Alcohol abuse	1.9	2.9	0.11
Depression	3.4	6.6	<0.01
Family history of CAD[a]	17.6	24.4	<0.01
COVID 19 Infection	0.2	0.4	0.16
Primary expected payer (%)			<0.01
Medicare	1.7	5.1	
Medicaid	22.8	24.9	
Private insurance	56.5	49.4	
Self-pay	13.0	15.4	
No charge	1.0	1.1	
Median household income (%)			<0.01
0–25 percentile	27.8	33.0	
26–50 percentile	25.8	28.1	
51–74 percentile	25.7	23.3	
76–100 percentile	20.6	15.6	
Bed size of hospital (%)			0.14
Small	15.4	15.2	
Medium	26.2	29.7	
Large	58.4	55.1	
Location/teaching status of hospital (%)			0.05
Rural	55.8	72.3	
Urban/nonteaching	24.5	21.1	
Urban teaching	69.9	71.7	
Regional of hospital (%)			<0.001
Northeast	17.7	15.7	
Midwest	15.8	24.8	
South	44.1	43.0	
West	22.3	16.5	
Charlson Co-morbidity Index Score			<0.01
0	0	0	
1	65.8	46.7	
2	27.0	34.7	
≥3	7.2	18.6	

[a] S.E.: Standard Error, CAD: Coronary Artery Disease, COPD: Chronic Obstructive Pulmonary Disease, ACE: Angiotensin Converting Enzyme, SMuRF: Standard Modifiable Cardiovascular Risk Factor, IQR: Interquartile range, CAD: Coronary Artery Disease, COPD: Chronic Obstructive Pulmonary Disease, ACE:

Angiotensin Converting Enzyme, SMuRF: Standard Modifiable Cardiovascular Risk Factor.

(aOR, 0.4 [95 % CI, 0.2–0.9]; $P < 0.01$). No significant differences were observed in length of stay and total hospitalization cost after adjusting for yearly inflation using the consumer price index. The median number of hospitalization days was two days in both cohorts, and the median total cost was $19,328.09 (IQR; $14,525.61 to $26,522.97) vs. $18,271.5 ($14,353.63 to $27,573.70), $P = 0.54$ in patients with and without SMuRFs respectively. Refer to Table 2 for more details.

After adjusting for sex, race/ethnicity, income, hospital characteristics, and co-morbidities, independent predictors of mortality among SMuRF-less patients include coagulopathy (aOR, 8.1 [95 % CI, 2.2–29.3]; $P < 0.01$), fluids, electrolyte abnormalities (aOR, 11.9 [95 % CI, 4.2–33.8]; $P < 0.01$) and cardiogenic shock (aOR, 9.8 [95 % CI, 2.2–43.5]; $P < 0.01$) (Fig. 2).

Table 2
Proportions and adjusted in-hospital outcomes of SMuRF-less patients presenting with STEMI.

In-hospital outcomes	Overall	SMURF-less	≥1 SMURF	*P*-value
All-cause mortality				
Proportions (%)	2.5	8.0	2.0	<0.01
Unadjusted OR		4.2 (3.1–5.8)	Reference	<0.01
Adjusted OR		2.6 (1.5–4.2)	Reference	<0.01
Acute heart failure				
Proportions (%)	8.7	11.0	8.6	0.02
Unadjusted OR		1.3 (1.1–1.7)	Reference	<0.01
Adjusted OR		2.1 (1.5–2.9)	Reference	0.01
Cardiogenic shock				
Proportions (%)	6.8	14.9	6.1	<0.01
Unadjusted OR		2.7 (2.1–3.4)	Reference	<0.01
Adjusted OR		1.8 (1.3–2.5)	Reference	<0.01
Cardiac arrest				
Proportions (%)	4.8	10.7	4.3	<0.01
Unadjusted OR		2.7 (2.1–3.5)	Reference	<0.01
Adjusted OR		1.8 (1.3–2.5)	Reference	<0.01
Acute stroke				
Proportions (%)	0.7	1.1	0.6	0.12
Unadjusted OR		1.8 (0.8–3.8)	Reference	0.12
Adjusted OR		0.9 (0.3–2.9)	Reference	0.99
Acute kidney injury				
Proportions (%)	9.2	14.8	8.6	<0.01
Unadjusted OR		2.8 (1.5–2.3)	Reference	<0.01
Adjusted OR		1.4 (1.0–1.9)	Reference	0.02
Ventricular fibrillation				
Proportions (%)	7.9	14.5	7.2	<0.01
Unadjusted OR		2.1 (1.7–2.7)	Reference	<0.01
Adjusted OR		1.4 (1.0–1.9)	Reference	0.03
Ventricular tachycardia				
Proportions (%)	12.9	16.3	12.6	<0.01
Unadjusted OR		1.3 (1.1–1.6)	Reference	<0.01
Adjusted OR		1.0 (0.9–1.3)	Reference	0.75
Vasopressor use				
Proportions (%)	1.5	3.7	1.3	<0.01
Unadjusted OR		2.9 (1.9–4.5)	Reference	<0.01
Adjusted OR		1.5 (0.9–2.8)	Reference	0.15
Pacemaker implantation				
Proportions (%)	0.1	0.1	0.1	0.99
Unadjusted OR		1.1 (0.1–8.6)	Reference	0.93
Adjusted OR		0.7 (0.04–17.3)	Reference	0.88
Intra-aortic balloon pump				
Proportions (%)	4.4	7.7	4.1	<0.01
Unadjusted OR		1.9 (1.4–2.5)	Reference	<0.01
Adjusted OR		1.3 (0.9–1.9)	Reference	0.16
ECMO[a]				
Proportions (%)	0.3	1.6	0.2	<0.01
Unadjusted OR		8.1 (3.7–17.9)	Reference	<0.01
Adjusted OR		4.11 (1.1–15.1)	Reference	0.03
PCI[a]				
Proportions (%)	64.8	56.5	65.5	<0.01
Unadjusted OR		0.7 (0.6–0.8)	Reference	<0.01
Adjusted OR		0.7 (0.6–0.8)	Reference	<0.01
CABG				
Proportions (%)	2.5	1.3	2.6	<0.01
Unadjusted OR		0.5 (0.2–0.9)	Reference	<0.01
Adjusted OR		0.4 (0.2–0.9)	Reference	<0.01

[a] ECMO: Extramembrane corporeal oxygenation, PCI: Percutaneous coronary intervention, CABG: Coronary Artery Bypass Graft.

5. Discussion

This nationwide study evaluated the prevalence, predictors, and in-hospital outcomes of young patients without SMuRFs presenting with STEMI in the United States. Our principal findings show that 8.3 % of young patients presenting with STEMI do not have traditional cardiovascular risk factors. At baseline, SMuRF-less patients were more likely to be younger and have heart failure, liver disease, and coagulopathy; they were, however, less likely to have obesity and a family history of coronary artery disease. In evaluating in-hospital outcomes, having no SMuRFs was associated with higher in-hospital mortality and STEMI-related complications, including acute heart failure, cardiogenic shock, cardiac arrest, acute kidney injury, and ventricular fibrillation. Additionally, SMuRF-less patients were less likely to undergo percutaneous coronary intervention and coronary artery bypass graft. Cardiogenic shock, coagulopathy, and fluid and electrolyte abnormalities are independent predictors of higher mortality in SMuRF-less patients.

Advances in cardiovascular risk factor identification have led to the development of mitigation strategies and guideline-directed medical therapies (GDMT) aimed at reducing cardiovascular events. These therapies have targeted traditional risk factors such as hypertension, hypercholesterolemia, diabetes mellitus, and smoking. Increasingly, the burden of evidence suggests other non-traditional cardiovascular risk factors not only play a role in the etiology of acute coronary syndrome but may contribute to driving morbidity and mortality. In our study, 8.3 % of young patients who presented with STEMI had no SMuRFs. While this proportion may be lower than the reported estimate of 11 % to 27 % of all patients presenting with ACS, it is comparable to a similar study of young patients with STEMI *Kelly* et al. that reported a similar proportion (8.4 %) of SMuRF-less patients. [22] Higher utilization of mechanical circulatory support devices including extramembrane corporeal oxygenation (ECMO) among SMuRF-less patients, suggests a higher disease burden complicating STEMI presentation. In one study, SMuRF-less patients were found to have higher rates of left anterior descending artery (LAD) involvement, which may contribute to higher disease severity. [22] Of note, in our study, SMuRF-less patient cohorts have a higher proportion of heart failure at baseline, which may explain the higher rates of cardiogenic shock observed in our study. The prognostic significance of heart failure in patients with acute coronary syndromes is well documented. The presence of heart failure in patients admitted with ACS is associated with a 4-fold increase in crude hospital mortality and was an independent predictor of mortality regardless of subtype of ACS. [23] The inter-dependency between the kidney and the heart, often described as cardiorenal syndrome, highlights the relationship between higher rates of cardiogenic shock and acute kidney injury observed in SMuRF-less patient cohorts. Fluid and electrolyte imbalance, which is an independent predictor of mortality among SMuRF-less patients in our study, may result from a disturbance of the body's homeostasis due to acute kidney injury and can increase the propensity for arrhythmias such as ventricular tachycardia and fibrillation with consequent cardiac arrest and death. [24–26] Interestingly, the lower obesity rate observed in SMuRF-less patients in our study and several other studies suggests obesity may not be the main driver of excess mortality or atherosclerosis. [7,11,27]

Our study adds to the existing literature on SMuRF-less young patients in many ways. The application of several exclusion criteria, such as SCAD, cocaine-related STEMI, and takotsubo cardiomyopathy, enabled the identification of patients presenting with atherosclerotic disease-related STEMI as an index admission. We found that SMuRF-less young patients were 30 % less likely to undergo percutaneous coronary intervention (PCI) and 60 % less likely to undergo coronary artery

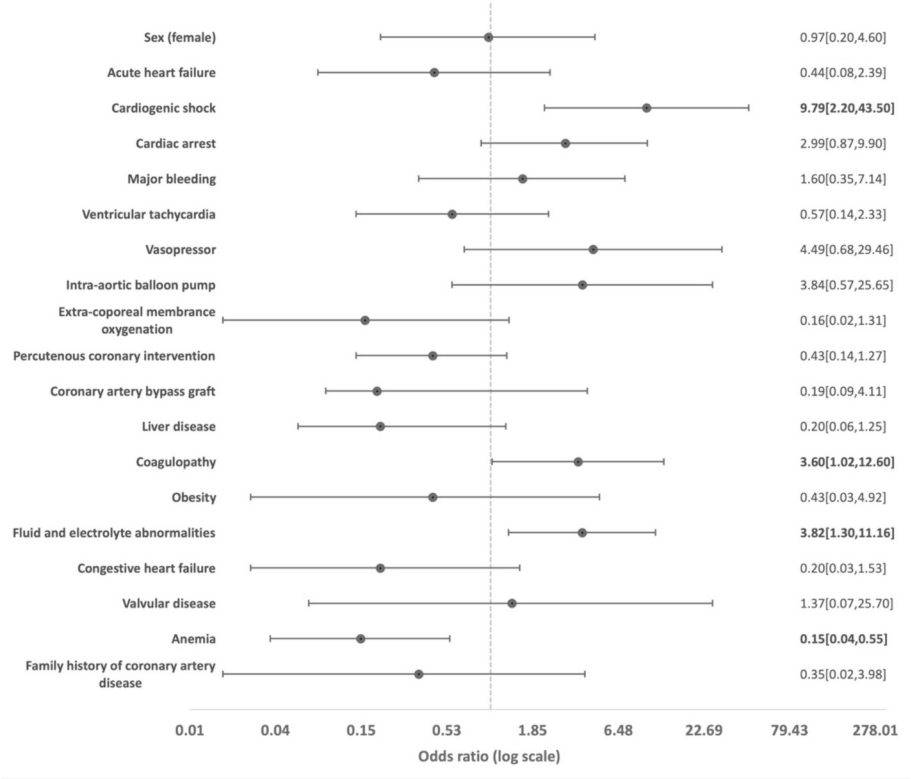

Fig. 2. Predictors of Mortality in SMuRF-less Patients Presenting with STEMI.

bypass graft (CABG). While this represents a significant deviation from the standard of care, other studies have reported similar findings [16,28]. Presumably, these patients may be too sick to survive the stress of undergoing these interventions. Some studies have also reported differences in clinical presentation, with SMuRF-less patients being less likely to have chest discomfort or be admitted to cardiac wards, as well as variations in procedural practices, including longer door-to-balloon time which may worsen in-hospital outcomes. [28,29] This represents a significant area of unmet need in the care of SMuRF-less patients with direct implications on in-hospital outcomes and mortality. Lastly, we have demonstrated that higher mortality and worse STEMI-related complications reported in many studies hold true even among young patients despite their lower co-morbidity burden compared to older adults.

The impact of other non-traditional cardiovascular risk factors such as nutrition and exercise, obstructive sleep apnea, oral health and periodontal disease, genetics, thrombotic factors, gender, inflammatory disorders, and psychological and social factors have also been proposed as potential players in the etiology and evolution of atherosclerotic disease. [30] For example, obstructive sleep apnea has been proposed to promote cardiovascular disease through intra-thoracic pressure alterations in cardiac and pulmonary vascular hemodynamics, sleep fragmentation, and intermittent hypoxia. Intermittent hypoxia which causes several cycles of deoxygenation and reoxygenation, promotes systemic inflammation, sympathetic excitation and vascular endothelial dysfunction are precursors of atherosclerosis. [31] Additionally, other environmental factors such as passive tobacco smoking, and psychosocial factors such as depression have been implicated in coronary artery disease and worse outcomes after a cardiovascular event. Screening tools targeted at identifying and intervening in patients with these risk factors may improve health outcomes. [32,33] While the main driver of excess mortality observed in SMuRF-less patients presenting with STEMI remains unclear, the utilization of certain drug classes such as antiplatelets, beta-blockers, statins, and angiotensin-converting enzymes inhibitor/angiotensin receptor blocker therapies which may be more prevalent in patients with SMuRFs may confer some mortality benefits. [11,16,28] Additionally, some studies have shown that SMuRF-less patients are less likely to received other guideline directed medical therapy at discharge [12]. Although our study did not account for laboratory biomarkers, Lipoprotein (a), an atherogenic and prothrombotic molecule that confers independent risk for cardiovascular disease, may also play a role in coagulopathy driving mortality in SMuRF-less patients as identified in our results [34,35].

In this study, the inherent design of our database presents some limitations. This study delineates associations between SMuRF-less patients and patients with poor in-hospital outcomes; however, due to the retrospective nature of our study, causality cannot be established. The utilization of the *International Classification of Diseases (ICD) code* has the potential for coding errors. Additionally, long-term outcomes were not analyzed as these results may differ, although prior similar studies reported higher mortality at thirty days, one year, and two years. [16,22] In analyzing our data, we could not account for angiographic and echocardiographic data. Our database does not include laboratory data, including novel biomarkers and medications, and as such, their utilization and impact on patient outcomes could not be analyzed. Lastly, given our sample size, a disaggregated analysis of outcomes based on various regions of myocardial involvement could not be performed.

6. Conclusion

Our study demonstrated that patients without standard modifiable cardiovascular risk factors presenting with ST-elevation myocardial infarction have worse in-hospital outcomes. This holds true even for young patients who have different cardiovascular risk profiles and are often understudied and underrecognized. Several factors, including atypical clinical presentation, in-hospital procedural differences, variations in regions of myocardial infarction involvement, the utilization of guideline-directed medical therapy including angiography and

revascularization, and non-traditional risk factors may play a role in poor outcomes among SMuRF-less patients presenting with STEMI. Further studies are needed to identify biomarkers, quantify the impact of non-traditional risk factors, and develop screening methods for early detection of atherosclerotic disease while improving preventive strategies in coronary artery disease.

CRediT authorship contribution statement

Garba Rimamskep Shamaki: Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Israel Safiriyu:** Writing – original draft, Methodology. **Akanimo Antia:** Writing – original draft, Software. **Waddah K. Abd El-Radi:** Writing – original draft. **Chiwoneso Beverley Tinago:** Writing – review & editing, Writing – original draft. **Onyedika Ilonze:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Statement of authorship

This author takes responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

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Appendix A. Supplementary data

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